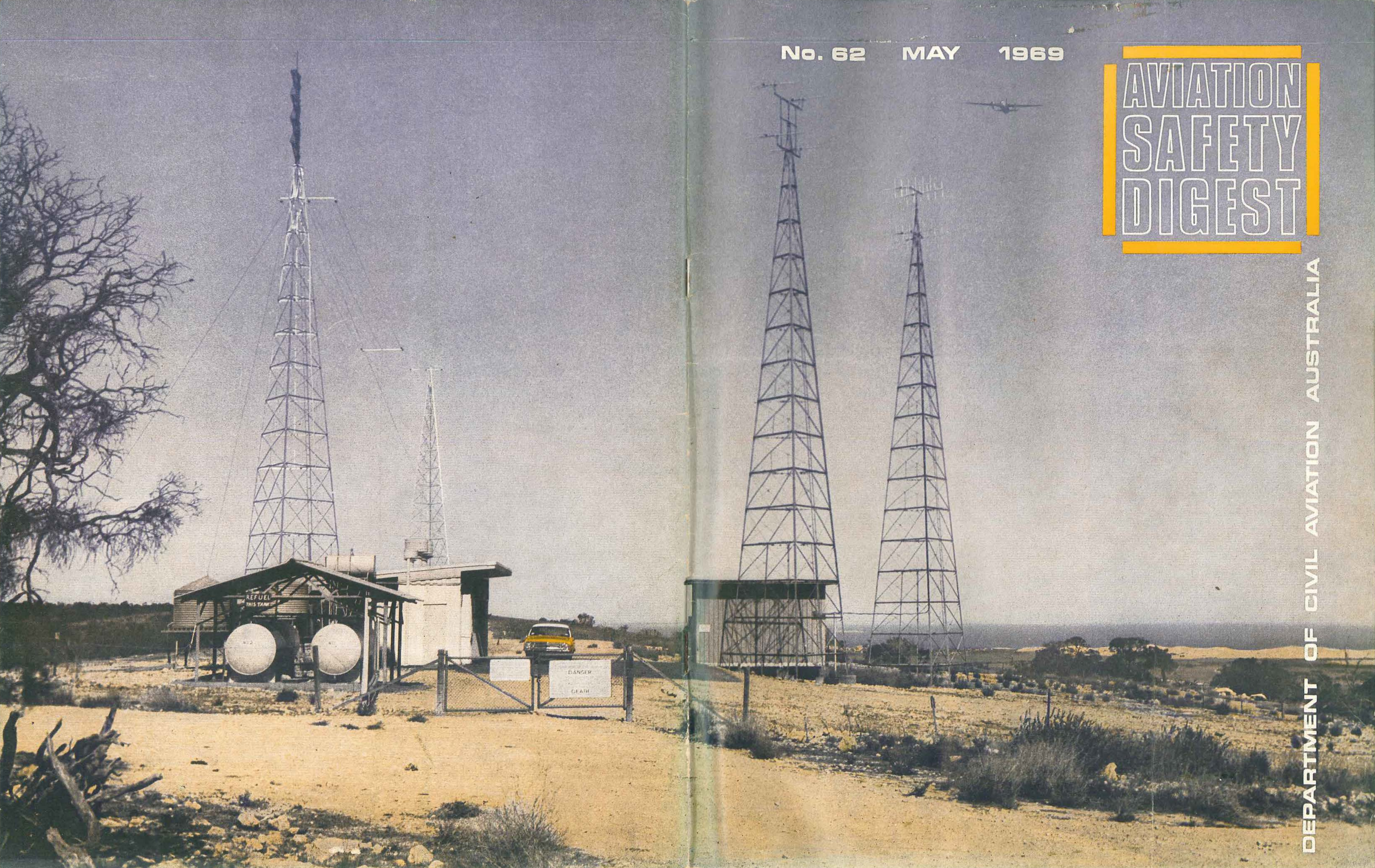
No. 62 MAY 1969

AVIATION SAFETY DIGEST



DEPARTMENT OF CIVIL AVIATION AUSTRALIA

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No. 62 MAY, 1969

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Contents

COVER: (Front and Back) Outpost of empire. Well known as a reporting point, but probably never seen at close quarters by those who use it most, the radio navigational aid complex at Mt. Hope, on the eastern shore of the Great Australian Bight, exemplifies the far flung character of the Department's airways facilities network. The picture, together with the inset at left showing technicians checking the calibration of the Mt. Hope VOR in conjunction with a specially equipped Fokker Friendship of the DCA Flying Unit, was taken during one of the periodic surveys which the Department makes of all radio navigational aids for which it is responsible.

AUSTRALIA

Printed by The Ruskin Press Pty. Ltd., 39 Leveson Street, North Melbourne

This insurance is cheap . . . .

In the last issue of the Digest, there was an account of an overseas accident in which the crew of a Boeing 727 survived a take-off accident but sustained injuries which might otherwise have been avoided if they had been wearing the shoulder harness provided on the flight deck of the aircraft. As a result of this accident, the National Transportation Safety Board in the United States recommended that checking shoulder harness should be included as an item in pre-take-off and pre-landing check lists of airline aircraft.

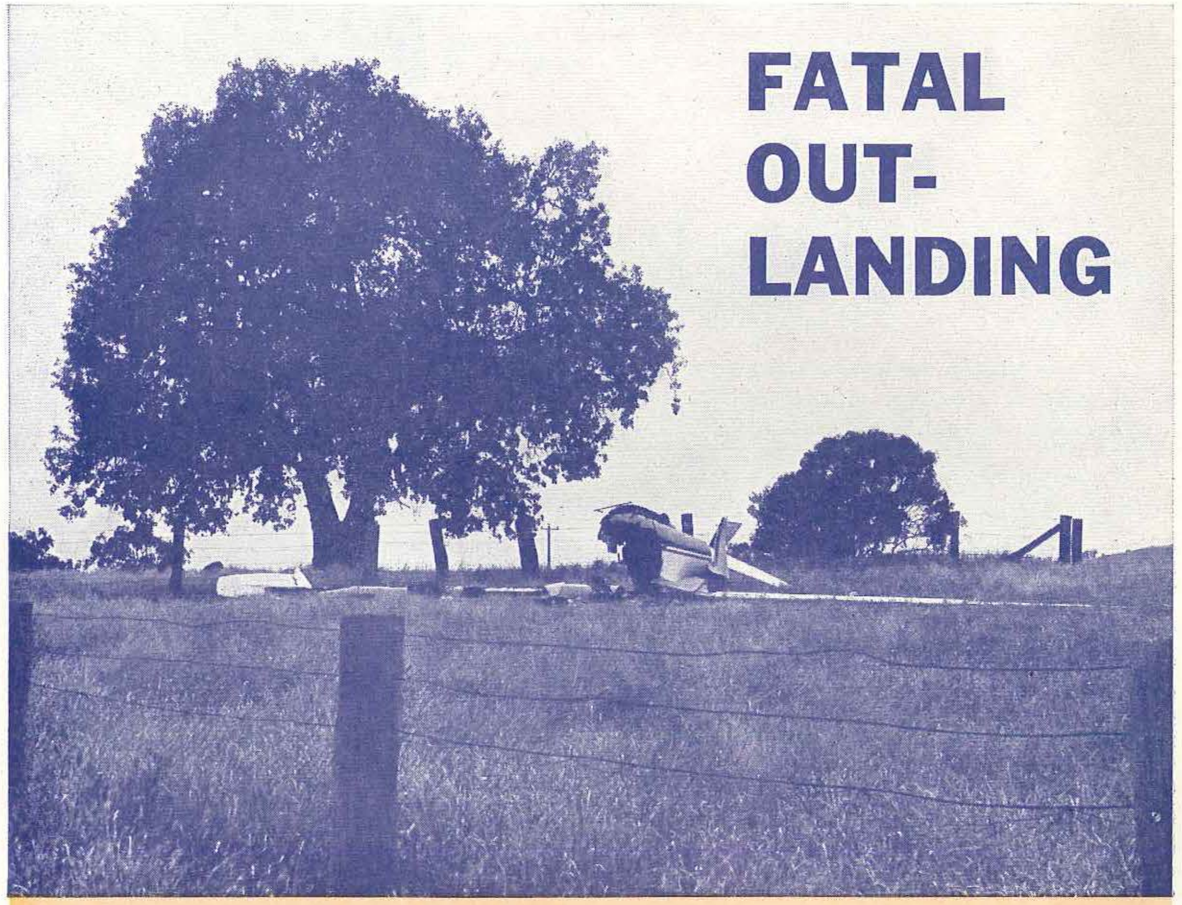
On page 2 of this issue, there is a case from the opposite end of the aircraft performance scale, in which a glider pilot lost his life in a landing accident. Despite the catastrophic nature of this accident, and the fact that the structure of the glider was largely demolished in the impact, it seems quite probable that the pilot would have survived if his restraint harness had not given way. The subsequent tests made on the glider's restraint equipment showed it to be sub-standard both in regard to the manner of its original construction and the unauthorised repair that had been made to it sometime in the past. Its "insurance value" as crash survival equipment was thus largely negated from the time the harness was installed in the aircraft.

The belief that "it can't happen to me" is probably present to a greater or lesser degree in all of us. But logically, if there were any justification for this belief, it would be quite unnecessary to apply measures for accident serviceability. It would be absurd to suggest that any sane person would be prepared to go as far as this, but nevertheless, whenever we strap ourselves into an aircraft, an element of feeling undoubtedly remains that we are not going to need the safety harness we are putting on. The natural inference is that it doesn't matter if the harness's condition leaves a little to be desired, or if it is not properly adjusted to provide the proper degree of restraint.

To be of any real value, crash survival equipment in aircraft needs to be treated seriously. Without adopting a morbid attitude to the chances of becoming involved in an accident, individual pilots, as well as operators, need to examine the accident possibilities in relation to their type of operations. The inevitable conclusion should be that although individual pilots can do much to eliminate accidents, accidents **can** still happen and **can** still involve him just as much as "the other fellow". Operators and pilots alike should therefore realistically assess the degree of protection that the equipment installed in their aircraft affords. This assessment should not be limited to determining the adequacy or otherwise of seat belts or safety harness — it should embrace such matters as the efficacy of crash padding, the possible use of crash helmets, and whether any non-standard fittings in the aircraft could pose a threat to the occupants in the event of an accident. The outcome of such assessments will, of course, vary with the type of operation and aircraft concerned, but it could range from fitting a new safety belt in the cockpit of an ultra-light to a decision to wear the shoulder harness provided on the flight deck of a regular public transport jet.

To do less than this is merely to pay lip service to the need for crash protection in aircraft. It hardly needs to be said that such "agreement in principle" would be of little avail if ever one's philosophy should be put to the test.

FATAL OUT-LANDING



Approaching to land in a small field near Wodonga, Victoria, a Vogt LO-150 sailplane touched down at comparatively high speed and bounced back into the air. As the glider continued to float, the pilot attempted to lift it over a tree which lay in the landing path. The glider nosed-up sharply, struck the upper branches of the tree, and plunged to the ground in a near-vertical attitude. The impact demolished the glider and the pilot was fatally injured.

The pilot held an F.A.I. "C" Certificate and had flown a total of 67 hours, 24 of which had been on the LO-150 glider. The glider had been winch-launched into the air at Corowa soon after 1130 hours on the day of the accident for the pilot to attempt a cross-country flight, Corowa-Benalla-Albury-Corowa, as part of his qualification for the "Silver C" award. The day was fine and hot with little wind, and after gaining height in the Corowa area, the pilot set out for Benalla at 1215 hours, and reached this first turning point at 1405 hours at 4,000 ft. Heading towards Albury on the second leg of his flight, the pilot passed over Glenrowan at 1435 hours and soon afterwards reached the height of 6,800 ft. At 1520 hours, he was over Chiltern, 20 miles south-west of Albury at 5,400 ft. and had Albury in sight. Fifteen minutes later he reached Wodonga, only five miles south of Albury, but was now down at 4,200 ft. From this point on, the pilot experienced a continual loss of height and at 1550 hours he was down to 2,500 ft. at Bonegilla, five miles east of Wodonga. At about 1600 hours, a group of soldiers walking back to their camp along the Murray Valley highway just to the east of Bonegilla, sighted the glider at low altitude flying almost parallel to the highway. As they watched, it approached to land in a paddock adjoining the highway. The glider touched down at the top of a rise in the paddock, bounced to a height of about four feet, and floated on towards a 45 foot high tree in the centre of the landing path. Shortly before reaching the tree, the glider climbed sharply but it struck the tree high up on the left side with its starboard wing. The glider rolled on to its back, the nose dropped and the aircraft struck the ground in a steep nose down attitude, and fell over on to its back. The eye witnesses immediately vaulted the fence and ran to the wreckage where they rendered assistance to the badly injured pilot until an ambulance arrived.

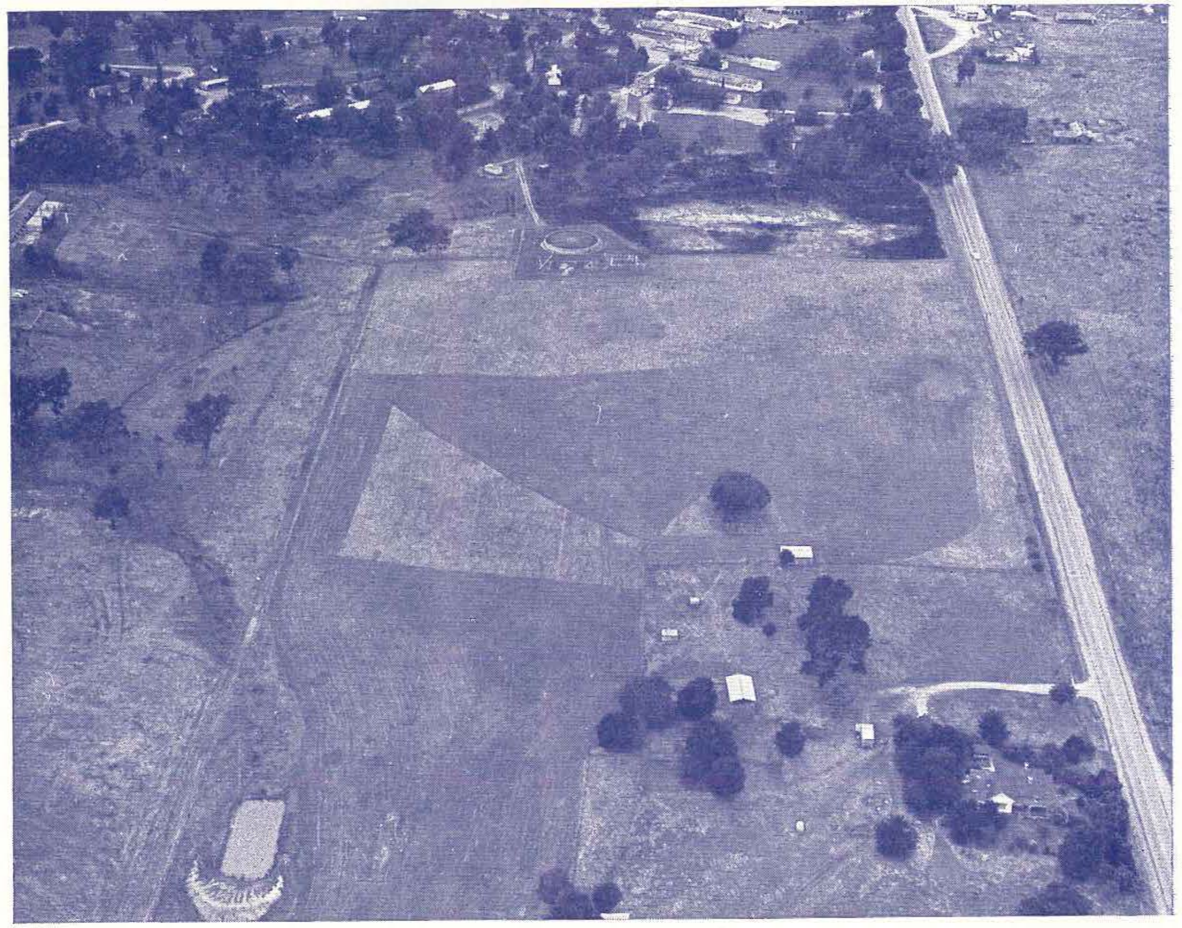
* * *

The structure of the glider was almost completely destroyed by the impact, only the starboard wing and tail assembly escaping major structural damage. The forward part of the cockpit shell had disintegrated completely and it was found that the pilot's lap strap had failed under the impact load, allowing the pilot to fall out of his harness. The pilot's seat itself and the harness attachment fittings remained intact. A recording barograph and notes made by the pilot during the course of his flight, were found in the wreckage and from these it was possible to reconstruct the progress of the flight.

From the barograph trace and the pilot's notes, it is apparent that the pilot was forced to land in the Bonegilla area when the second of the planned cross-country legs was almost completed. The barograph trace shows the glider ran steadily out of lift from a point south of Wodonga, and the pilot had evidently turned towards Bonegilla in an unsuccessful attempt to find a thermal.

Most of the level ground in the Bonegilla area is dotted with trees and there are few areas in which a glider can be landed safely. To obtain an appreciation of the problem that would have faced the pilot in deciding where to land when it became obvious that he would be forced to do so, a Depart-

Below: The paddock in which the pilot attempted to land. The direction of the glider's approach was towards the camera, over the buildings in the background. The tree that the glider struck is near the centre of the picture.



mental investigator surveyed the Bonegilla area from a light aircraft flying at 1,500 ft. It was apparent from this survey that there were two areas in which the pilot might have chosen to land. To the north of Bonegilla, but within gliding distance of the field in which the landing attempt was actually made, there was an open area of ample dimensions adjacent to the Hume Reservoir. Although the surface of this area looked satisfactory, its suitability for a landing could not be conclusively determined from the air. The other available area where the accident actually occurred was an L-shaped field which looked much better from the air than the ground. From the air, it was also obvious that it had been under agriculture in the recent past and for this reason it seems likely that the pilot might have been more confident of its surface condition. As well as this, the field adjoined a major road and was close to habitation and altogether offered better facilities for the recovery of the glider than the other area farther to the north.

The evidence of eye witnesses indicates that the glider approached the field from the east parallel and near to the road adjoining the southern side of the field, an approach path which could not make full use of the available length. From this direction also, an undulation in the ground rises to a point midway between the eastern boundary of the field and the tree struck by the glider. The ground then falls away again to the north and west. Thus, from low on the pilot's approach, this latter part of the field would have been hidden by the rise. It is evident from the eye witnesses' description of the glider's approach, and the initial touch-down, that the pilot had forced the aircraft down on to the rising ground, probably in the hope of slowing the glider on the area of the field within his view. This attempt was obviously unsuccessful and the glider bounced back into the air and continued to float.

The pilot would no doubt have had the spoilers extended at the time of the initial touchdown, but it seems likely that, when he saw he would be unable to land before reaching the tree, he would have released the spoilers and attempted to manoeuvre around or over the tree. A turn to the left would have taken the glider towards a timbered area, at the side of the field, and the glider's approach path was evidently such that a turn to the right would have brought it into collision with the tree. The pilot was thus left with no alternative but to attempt to climb over the tree and make the best landing possible in the section of the field that remained. The steep climb that was necessary to clear the tree was evidently sufficient to stall the glider, and the starboard wing's impact with the upper branches of the tree, combined with the effect of nose-up elevator in a stalled condition, caused the glider to roll into an inverted attitude before its nose dropped and it plunged to the ground.

As well as the fact that the area of the field the pilot had selected for the landing was unsuitable, it is clear that the pilot also made an error of judgement in planning his final approach. The result was that the glider's speed was too high at the point where the pilot intended to touch down. An examination of the pilot's log book, made to determine what experience he had in operations of this type, showed that he had made only two previous out-landings. One of these had taken place eight months before the accident, and the other 16 months before.

To establish the reason for the failure of the pilot's lap strap and the result this might have had on the outcome of the accident, the complete restraint harness was removed from the glider for detailed examination and testing. The harness anchorage points in the glider were also examined, but exhibited no signs of overload.

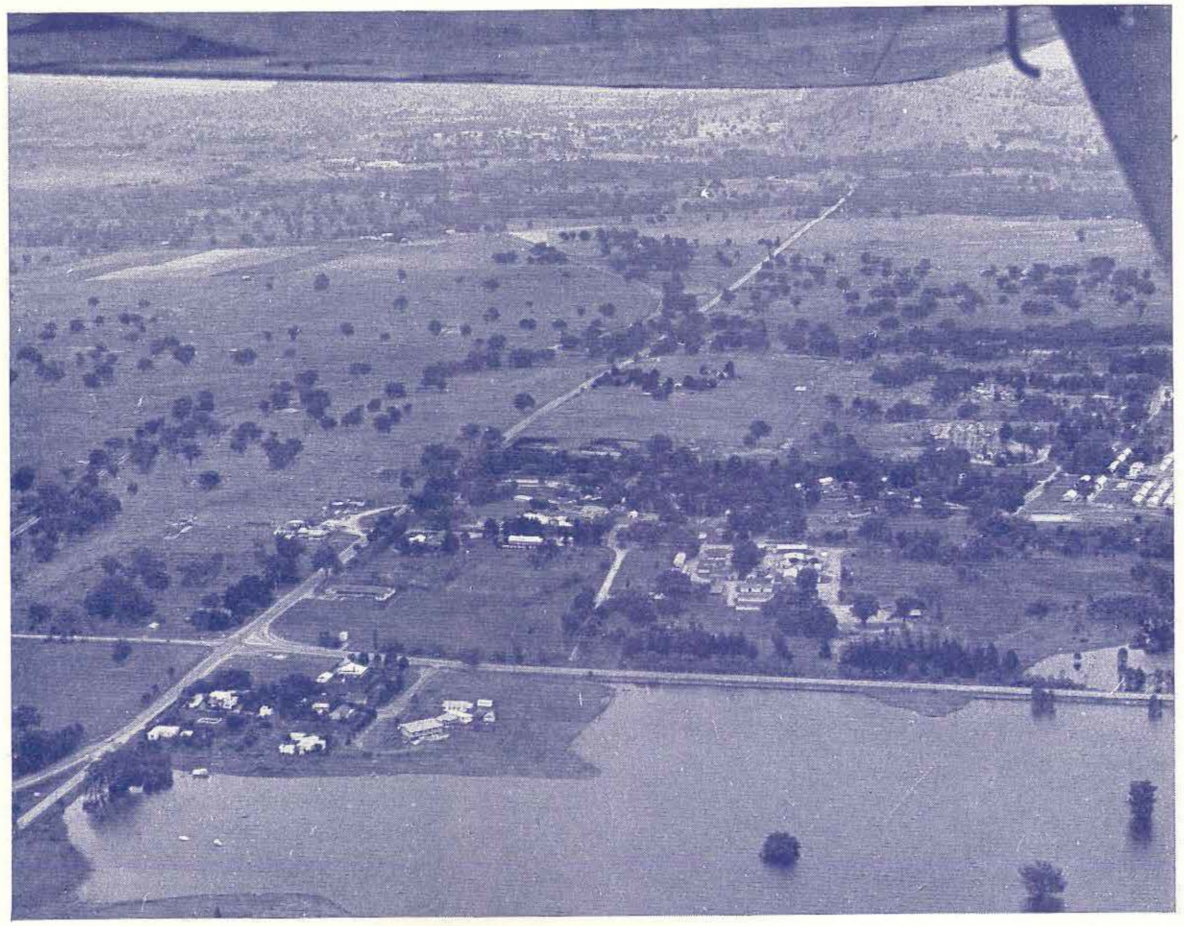
Tests carried out by the Aeronautical Research Laboratories on the intact portion of the lap strap and the unbroken shoulder harness showed that all three straps were well under the minimum strength specified by the Department. The harness was not of an approved type and it was found that it had been subjected to an unauthorised and unsatisfactory repair several years before. Cotton thread had been used on terylene material and the stitching itself had been carried out in a box pattern only, with no diagonals. Calculation of the forces that would have been imposed on the harness at the time of impact showed that although these were in excess of the strength of the restraint harness fitted to the glider, the force imposed would have been less than the strength of a serviceable harness. Provided the harness attachments had held therefore a serviceable harness of an approved type should have restrained the pilot in his seat and, as the seat had remained intact, the accident might have been survivable in these circumstances.

Cause

The cause of the accident was that the pilot, who was inexperienced in out-landings, attempted to land the aircraft in an unsuitable area.

Comment

There are three very clear object lessons to be derived from this tragic accident. One of these, relating to the adequacy of safety equipment, is of such significance and of such general application, that it has been made the subject of an editorial in this issue of the Digest. The other two relate to out-landings and apply specifically to glider flying.



General view of the area in which the pilot was forced to land. The paddock the pilot chose can be seen in the centre of the picture immediately to the right of the road. The photograph is taken looking in the approximate direction of the glider's final approach.

In any cross-country attempt and particularly in those being flown for an award or in competition, there is an understandable reluctance on the part of a pilot to finally admit defeat when he appears to be running out of lift. In such circumstances, a pilot is tempted to defer committing himself to a landing until the last possible moment in the hope he will be able to locate the elusive area of lift that can save him from the ignominy of failing to complete the course. There is no direct evidence that this was a contributing factor to the Bonegilla accident, but its circumstances are such that this might well have been so. Whatever the actual situation was in this case however, the point remains valid for flights of this type. In recent months there have been a number of instances where out-landings have ended in accidents, solely because the pilots concerned left it too late to plan a proper approach.

The final point to be noted is also related to out-landings. It is the obvious need to choose a field which offers an adequate margin of safety for the landing. Glider pilots must guard against allowing their choice of a field to be compromised by considerations of the ease of recovering the glider. Glider flying has often been the butt of the old joke that "every landing is a forced landing". No doubt this accusation would be denied by gliding enthusiasts, but there is an element of truth in it and it is certainly so in the case of an out-landing made when a glider runs out of lift. Such a landing is in fact the equivalent of a forced landing in a powered aircraft and should be regarded in the same light. The difficulties involved in retrieving a glider from an inaccessible paddock, while they might prove irritating at the time to those concerned, are of little consequence compared with the cost of repairing a substantially damaged aircraft. When related to the possible results of an accident like the one reviewed in this article, the inconvenience caused by such an out-landing is insignificant.

MID-AIR COLLISION

(Summary of Report issued by National Transportation Safety Board, U.S.A.)

Three minutes after taking off from Asheville, North Carolina, U.S.A., a Boeing 727 collided with a Cessna 310 inbound to the airport. Both aircraft were destroyed and all 79 occupants of the Boeing and the three occupants of the Cessna were killed.

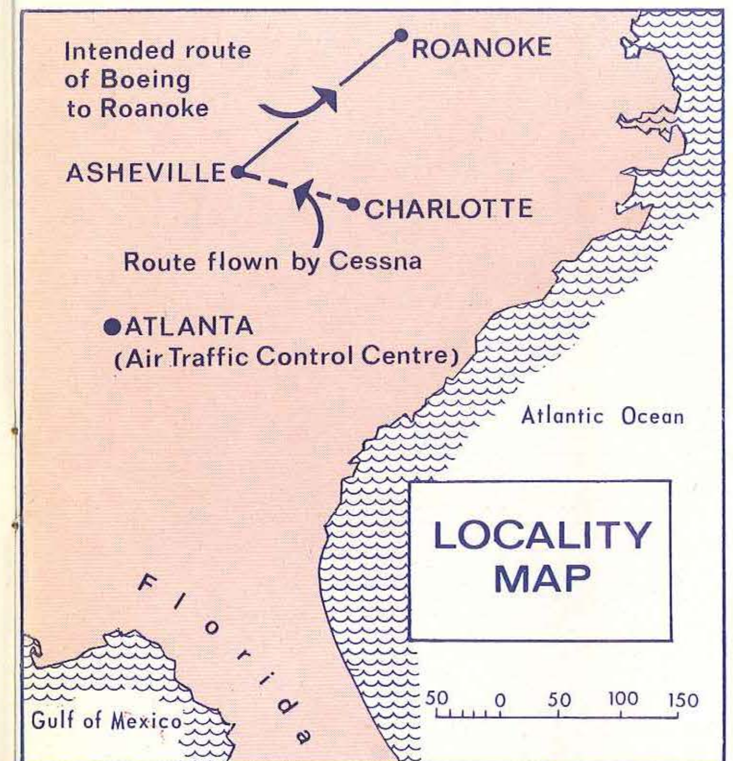
The Boeing, which had just departed on a scheduled airline flight, had taken off from Asheville airport's runway 16 at 1158 hours local time to proceed to Roanoke, Virginia. The Boeing was instructed to maintain the runway heading until reaching 5,000 ft. and was then cleared to climb unrestricted to the Asheville VOR.

The Cessna 310, which was engaged on a business flight under instrument flight rules, was arriving at Asheville from Charlotte, North Carolina. The Cessna had left Charlotte at 1130 hours and was cleared to cruise at 8,000 ft. The en-route portion of the flight was uneventful and at 1151 hours Atlanta Air Traffic Control Centre cleared the Cessna to the Asheville VOR and instructed it to descend and maintain 7,000 ft. The aircraft was also told to expect an ILS aproach at Asheville. The aircraft acknowledged this clearance and was subsequently advised that the radar service was terminated and was instructed to contact Asheville Approach Control.

At 1156 hours, Asheville Approach Control cleared the Cessna to overfly the VOR to the Asheville NDB. It was instructed to maintain 7,000 feet and report passing the VOR. The Cessna acknowledged the clearance and two minutes later, while the Boeing was actually making its take-off, the Cessna reported that it had just passed over the VOR and was "headed for the . . . Asheville now". The position report was acknowledged by Approach Control and the Cessna was instructed to descend and maintain 6,000 ft. The Cessna replied that it was leaving 7,000.

At 1200 hours, only seconds after clearing the Boeing to climb unrestricted to the VOR, Approach Control cleared the Cessna for an "ADF2" approach to runway 16 and instructed it to report over the Asheville NDB inbound. The clearance was acknowledged by the Cessna in what proved to be its last transmission.

Less than a minute later, as the Boeing was passing through 6,000 feet, some six miles east of the airport, and had just begun a shallow climbing turn to the left towards the Asheville VOR, the Cessna, flying level on a westerly heading, was seen converging on the Boeing. At the last moment, the Cessna was observed to nose-up sharply, but the two aircraft collided. The Cessna struck the forward section of the Boeing's fuselage low down on the port side and disintegrated. The Boeing continued straight ahead for a moment, then nosed over and dived rapidly to the ground



Map showing route flown by Cessna and proposed route of Boeing.

* * *

The wreckage of the two aircraft was scattered over an area a mile and a half long and half a mile wide, to the north and north-west of the main impact with the ground. Most of the components of the Boeing were found in the main wreckage area, with other fragmented portions scattered back along the flight path. The Cessna was severely fragmented and spread as far back as a mile and a half from the main wreckage area. The only identifiable portion of the Cessna found at the main wreckage site was the port engine, which was embedded in the lower forward fuselage of the Boeing 727. No evidence of any pre-impact failure or malfunction was found in the wreckage of either aircraft.

Little useful information could be obtained from the instruments and radio components of the Cessna because of the severity of the damage, but one of the two VOR receivers was found set to the Asheville ILS frequency. The aircraft's one ADF receiver appeared to be set to the frequency of the Broad River NDB. (See Chart on page 9)

The Boeing was equipped with a flight data recorder and a cockpit voice recorder, both of which were recovered from the wreckage in satisfactory condition. The flight recorder readout indicated that the collision occurred approximately 2 minutes 37 seconds after lift-off. It also showed that, after lift-off, the Boeing had maintained a heading of 160° for 1 minute 7 seconds to an altitude of 4,200 feet. At this point, a turn to the left was begun and maintained for 1 minute 20 seconds, until the collision occurred. The conversations recorded on the Boeing's cockpit voice recorder tape were mainly concerned with the operation of the aircraft, and there was no indication that any of the crew saw the Cessna before the collision.

There is no airport surveillance radar at Asheville, but four standard instrument approaches are published for the Asheville Airport: The VOR approach, an ADF-1 approach, an ADF-2 approach and an ILS approach to Runway 34. All these instrument approach procedures are based upon facilities in the Asheville area.

The ADF-2 procedure uses the Asheville NDB located 5.8 miles north-west of the airport on the extended centreline of Runway 16. The Asheville NDB is 17.4 miles north-west of the Asheville VOR on the 298 degree radial of that facility. The procedure requires a heading of 340 degrees to be flown outbound from the Asheville NDB with a procedure turn to be executed within 10 miles, at or above 5,500 feet, then an inbound heading of 160 degrees to cross the Asheville NDB not lower than 4,200 feet, at which point descent to the authorised minimum is commenced.

The ILS procedure uses the Broad River NDB as the primary approach fix. A procedure turn is executed on the outbound leg of the localiser, south-east of the Broad River NDB, to cross the Broad River NDB inbound on the localiser not lower than 5,000 feet, at which point descent to the authorised minimum is commenced.

* * *

It was clear that the Cessna had failed to comply with the clearance to proceed from the Asheville VOR to the Asheville NDB. The site of the collision, nine miles south-west of the VOR on the 243 degree radial, indicates a flightpath which would not have complied with any of the four published instrument approaches for Asheville.

The first event of significance took place at 1151 hours when the Cessna, still under the control of the Atlanta Centre, was advised to "expect an ILS approach at Asheville". United States ATC procedures require a Centre to be advised of the type of approaches being conducted at the various terminals within its area. In this case, Asheville Approach Control had informed the Atlanta Centre that ILS approaches were being conducted. It is also a required procedure for the Centre to advise an IFR flight of the type of approach to expect at the destination. This information is intended to provide a pilot with adequate time to review the approach procedure which he will most likely be required to use. It **is not** an approach clearance however, nor does it necessarily mean that it is the approach for which the aircraft will finally be cleared.

As the Cessna received this information five minutes before being cleared to the Asheville NDB, it can be assumed that the crew would have prepared for an ILS approach to Asheville. Their radios would have been set accordingly, and their attention given to the ILS chart. At 1153 hours, the radar serveillance service was terminated by the Atlanta Centre and control of the flight was transferred to Asheville Approach Control. In their first contact with Approach Control at 1153:49, the Cessna crew were not advised the type of approach they would be given on arriving at Asheville. The United States Air Traffic Control Procedures Manual provides that Approach Control facilities will notify an arriving aircraft at the time of first radio contact, or as soon as possible afterwards, of the type of approach to be expected when two or more approaches are published and the clearance limit does not indicate which will be used. This was not done. It appears that the controller did not know at that time what type of approach would be used and so was unable to provide this information. While this explanation is reasonable, it also is clear that, lacking such information, the Cessna crew would have proceeded on the basis of their most recent information, i.e., to expect an ILS approach. The crew's expectation of receiving ILS approach clearance was probably fortified shortly afterwards at 1154 hours, when another inbound aircraft was cleared for an ILS approach to Runway 16. At that time, both aircraft were on the Approach Control frequency and this clearance could have been heard by the crew of the Cessna.

The next communication with the Cessna was a clearance issued by Asheville Approach Control at 1156:28 as follows:

"Cleared over the VOR to Broad River, correction make that the Asheville radio beacon . . . over the VOR to the Asheville radio beason, maintain seven thousand, report passing the VOR."

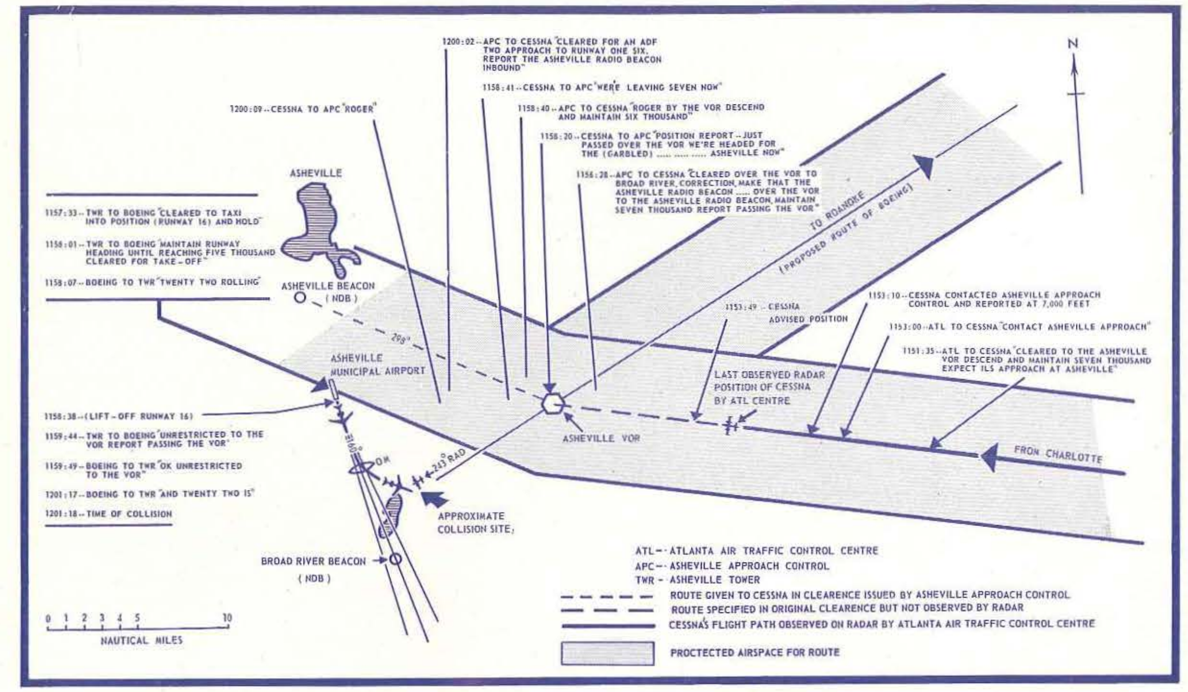
The clearance was acknowledged by the Cessna. This clearance, and the degree of its comprehension by the pilot, is most significant. It not only established a new clearance limit and route for the flight but also formed the basis for the separation required between the Cessna and the departing Boeing. To comply with instructions, it is apparent that the controller should have either specified a radial or heading to be flown, **or** specified "via direct" in his phraseology. There is no doubt that if the controller had specified the radial or heading from the VOR, i.e., " . . . over the VOR to the Asheville NDB, **(via the 298 degree radial of the Asheville VOR)** . . . " the possibility of misunderstanding or error would have been reduced.

In passing this clearance to the Cessna there was again no direct reference to the type of approach the flight was to be given. By this time, the controller should have been aware that the Cessna would be cleared for an ADF-2 approach rather than an ILS approach, and the clearance should have been a precise indication that an ILS approach was **not** to be used. However, the initial mention of the Broad River NDB in the clearance, which was immediately changed to Asheville, could have continued a chain of misunderstanding initiated when the Centre first advised the flight that they could expect an ILS approach. The ILS chart contained only one reference to the Asheville NDB, and that in the missed-approach procedure. It was not described by geographic location and the absence of a clear indication of its position, coupled with the correction made in the clearance, could very well have led the pilot to conclude that the Asheville NDB was associated with an ILS approach, either as the outer marker or, that its designation had been changed from Broad River NDB to Asheville NDB and that it was the change in name that prompted the controller's initial mention of Broad River instead of Asheville. In the absence of designating a radial to fly or, more importantly of, identifying the type of approach to be used, confusion could have been compounded, or a misunderstanding continued.

One minute 50 seconds after receiving the clearance, at 1158:20, the flight reported over the VOR as requested.

"Just passed over the VOR. We're headed for the . . . (Pause) . . . ah . . . Asheville now."

It is evident however, that the Cessna did not proceed towards the Asheville NDB (a heading of



Reproduction of chart prepared during investigation of accident, showing airspace boundaries in vicinity of Asheville, position of radio navigation aids, and flight paths of aircraft to point of collision.

298 degrees) after passing the VOR but instead flew a south-westerly heading. Although the controller was given no indication that the clearance was not understood, this transmission from the aircraft could indicate uncertainty as to where or what the "Asheville beacon" was. The words "we're headed for the . . . " would presume the use of a facility name such as 'Asheville beacon". Instead the sentence was completed after a four-second pause by the single word, "Asheville". There are many Asheville references in the terminal area and it is reasonable to believe that at this point too, there was confusion or misunderstanding as to the destination.

Finally, one minute 16 seconds before the collision, Approach Control cleared the Cessna for an ADF-2 approach to Runway 16, to report over the Asheville NDB inbound. This clearance was acknowledged, "roger", immediately and unhesitatingly. At this point, it should have become clear to the crew of the Cessna that they were not proceeding in accordance with their clearance and they should have immediately either reported their position or requested assistance.

The Board is unable to identify the specific reason for the Cessna's deviation from its clearance, but believes that it was the result of either confusion or misunderstanding of the clearance. In either event, it is concluded to be the product of two factors: (1) inadequate knowledge of the Asheville area by the pilot and poor flight planning, and (2) the failure of the ATC system to provide timely information that would have prevented the deviation, or at least alerted the pilot to recognise his misunderstanding.

Before reaching the Asheville area, the Cessna pilot should have reviewed and become familiar with all the approach charts for the airport. Had this been accomplished he should not have become confused or uncertain of the meaning of the clearance or the location of the Asheville NDB nor should he have misunderstood the clearance. Furthermore, when the clearance was received for an ADF-2 approach, approximately one minute before the accident, the Cessna pilot should have realized immediately that he had deviated from the clearance and either reported his position or requested assistance.

Concerning the operation of the ATC system, the Board recognises that it is not infallible. It requires a co-operative effort on the part of both pilots and controllers to achieve the desired results. If an inadequate clearance is issued by a controller, or if an adequate clearance is not followed precisely by a pilot, the intended margin of safety is decreased. A successful system must provide safeguards to protect against these inherent fallibilities. Where there is no surveillance radar, the only safeguard is complete adherence to clearances by pilots and, ideally, a method of air-to-ground communications which ensures absolute comprehension of instructions by pilots, and total assurance to controllers that clearances are being complied with. The scope of ATC practices and procedures in these areas must be maintained at a level where the possibilities for misunderstanding or confusion are reduced to an absolute minimum and which will, in turn, provide the maximum degree of tolerance in the system.

There can be no doubt that, if the controller had advised the Cessna to plan for an ADF-2 approach at the time of first contact, or at least when the clearance to the Asheville NDB was given, any confusion or misunderstanding as to the type of approach to be conducted, or the location of the Asheville NDB, would have been eliminated before passing the VOR. Not only should the controller have been aware that the flight had previously been advised to expect an ILS approach, but he must also have formulated in his mind the type of approach to which the flight was now to be cleared. In the circumstances, the delay in issuing this advisory must be considered a major factor leading to the events which followed. Notwithstanding the obvious omissions on the part of the crew of the Cessna, the lack of additional information from ATC to offest the previously issued advisory in all likelihood set the stage for the situation that developed. In addition, if the controller had specified a radial or bearing from the VOR to the Asheville NDB when issuing the clearance, any possible doubt as to the heading to be flown would have been eliminated.

Although a clearance readback is not mandatory, a request to this effect by the controller might have served to clear up any uncertainty in the mind of the pilot and perhaps might have alerted the controller to the fact that his instructions were not clearly understood. The clearance was obviously not complex; but there could have been no doubt in the mind of the controller that separation of the two aircraft was dependent upon the Cessna following a direct heading from the VOR to the Asheville NDB.

It appears to the Board, that controllers tend to use the same communication standards for both professional airline pilots and non-professional general aviation pilots. The Board believes that controllers should not equate all pilots with the upper segment of the proficiency spectrum. The Board is aware of the pressure imposed upon controllers by the near-saturation of the system, but it believes that this fact should not be permitted to limit necessary communications. All available information with respect to clearances should be given to pilots, and the practice of reading back clearances should be encouraged, particularly, as in this case, where time was clearly available. In the absence of radar surveillance to assure that the proper flightpath was being maintained, it appears that more positive steps could have been taken to ensure compliance with the clearance.

It must be stressed, however, that pilots are required to abide by the applicable provisions of the Federal Aviation Regulations with respect to ATC procedures, regardless of the application of any procedure or minima outlined in ATC procedures. If there is any uncertainty regarding compliance with an ATC clearance, the pilot is required to notify an ATC facility.

Probable Cause

The Safety Board determines that the probable cause of this accident was the deviation of the Cessna from its IFR clearance resulting in a flightpath into airspace allocated to the Boeing 727. The reason for such deviation cannot be specifically or positively identified. The minimum control procedures utilized by the FAA in the handling of the Cessna were a contributing factor.

Comment

With an increasing number of general aviation aircraft now using our primary airports, some of the National Transportation Safety Board's views have equal application to operations in Australia. Their comment is relevant to VFR traffic as well as to aircraft operating under Instrument Flight Rules.

The concept of utilizing the minimum advice consistent with clarity of instruction is an inherent characteristic of any air traffic control system designed to handle a heavy volume of traffic in a safe, efficient and expeditious manner. Because the great majority of persons expected to use the traffic control system will of necessity be experts in their field, such a system is designed to meet the needs of experts. If you are not yet expert in understanding and complying with the requirements of air traffic control—or if you are unsure of a particular instruction that has been passed to you, it is of the utmost importance that you convey your doubt to the controller. There can be no such thing as an "instant expert" and no one will blame you for making sure. So if ever you are in any doubt as to what you are to do in controlled airspace, speak up and ask for clarification.

Those New-fangled Retractable Undercarriages !

FROM the time when retractable undercarriages were first introduced in the early thirties, the secret fear of forgetting to lower the wheels for landing, and the humiliation resulting from such an omission, has haunted every pilot who has been privileged to operate such complicated pieces of machinery.

Recognising the problem that this advance in aeronautical design created, aircraft manufacturers over the years have tried to help the pilot by introducing various types of mechanical position indicators, instrument panel lights and warning horns to jog his memory and, more recently, even undercarriage levers that look like a landing wheel. With the advantages of all these memory aids, added to the fact that retractable undercarriages have now been on the aviation scene for more than 30 years and their drawbacks are extremely well recognised, it would be reasonable to imagine that landings made with the wheels unintentionally retracted would now be a thing of the past. Unfortunately, this is far from true and, time and again otherwise perfectly good aeroplanes are being consigned to the workshops for expensive repairs, simply because pilots are not properly completing their cockpit checks to ensure that the undercarriage is correctly extended before landing.

Recently, the National Transportation Safety Board in the United States released details of two accidental wheels-up landings, both involving highly experienced pilots. The principal findings of these accidents are contained in the Safety Board's latest issue of "Briefs of Accidents" covering the causes of more than 700 aircraft accidents. These two particular accidents were among ten similar ones, in which a contributing factor was that the pilot "failed to use check lists". In all ten accidents, the wheels-up landings were unintentional.

In one of the two cases mentioned, a pilot who held both commercial and flight instructor certificates and had a total of over 9,000 hours, landed a Beech Queenair wheels-up. Investigation showed that the pilot had not used a cockpit checklist for the landing and had made no final check of the undercarriage indicator. The undercarriage warning horn did not sound because the pilot had achieved his touchdown by controlling the fuel mixture rather than by closing the throttles — a practice which, he said, avoids "excessive engine backfiring". The throttles were thus not closed to the point where the warning horn would automatically sound.

The other accident involved a pilot who had logged 10,500 hours and was also the holder of both commercial and instructor certificates. His wheels-up landing was made in a Beech 18, which was substantially damaged. Again the pilot had no audible wheels-up warning because the landing had to be made at a higher than normal power setting to cope with turbulence and winds gusting to 24 knots.

Both accidents were described by the Safety Board as "prime safety lessons" for all pilots operating aircraft with retractable undercarriages. "There is no substitute for the use of the prescribed cockpit checklist to avoid accidental wheels-up landings," the Board said. In both these cases, one of them involving the distraction of turbulence, the warning horn was not able to save the pilot from the danger and the embarrassing consequences of forgetting to lower the undercarriage. Noting that the ten unintentional wheels-up landings listed involved pilots averaging nearly 5,000 hours each, the Board added "Never consider the unintentional wheels-up landing an accident that happens only to the inexperienced pilot. It is a potential accident for every pilot of a retractable gear aircraft. And when one of these pilots lands without using his checklists, he is asking for it to happen to him!"

Much of what the National Transportation

Safety Board has said could be applied with equal relevance to some of the wheels-up landing accidents that have occurred to Australian aircraft in recent years. It is significant that in Australia too, in nearly every case, the pilots concerned have been professionals with several thousand hours' flying experience. Here are a few Australian examples that have not previously been reported in the Digest:

Approaching the circuit area of his destination in a New South Wales country area just before last light, the pilot of a Cessna 210 changed the fuel tank selector to the other tank for landing but did not complete the full pre-landing check. Joining the circuit on a base leg, the pilot lowered full flap and made a slow, powered final approach, reducing speed in the later stages to 55 knots. As he flared for the landing, he realised the undercarriage was still retracted but it was then too late to go around and the aircraft settled on to the runway on its fuselage.

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In the British Solomon Islands, an Australian registered Beech Baron under charter to a British Solomon Islands Company was completing a scheduled passenger flight from Honiara. After a normal flight in favourable weather, the aircraft made a normal approach to land but touched down in a wheels-up configuration.

Examination of the aircraft showed that the undercarriage was fully retracted. When the aircraft was later jacked up, the undercarriage retraction mechanism was found to operate normally in every respect. The pilot, who was highly experienced, admitted that after the aircraft had come to a stop, the undercarriage selector was still in the up position, the red warning light on, and undercarriage position indicator showed undercarriage "up". The pilot said that he had been making a practice of "pulling" the warning horn circuit breaker and believed that he may have done this on this particular flight. He also admitted that he had failed to carry out the vital actions necessary to ensure the aircraft was in a proper condition for landing.

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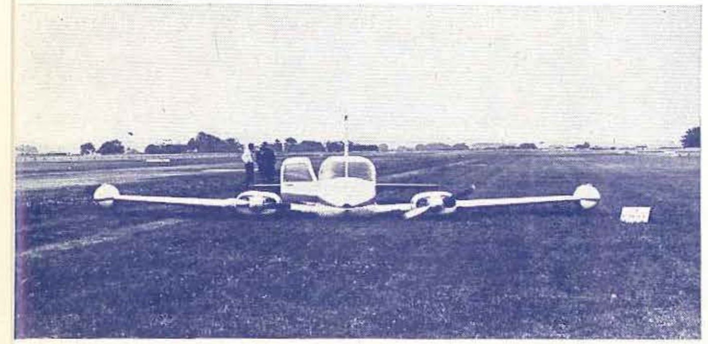
Arriving over Derby, Western Australia, after a flight from Broome, the pilot of a Debonair prepared for landing in gusty crosswind conditions. Carrying out his pre-landing check on the downwind leg of the circuit, the pilot began a final approach without flap, with the nose yawed into wind to compensate for drift. The aircraft crossed the threshold in turbulent conditions and in the hold-off position, the pilot aligned the aircraft with the runway. A moment later he heard the propeller tips striking the runway and the aircraft settled on to its fuselage with the undercarriage retracted.

The pilot said later that the undercarriage warning horn had not sounded until the aircraft was on the ground. Although the pilot believed that he had lowered the undercarriage during the pre-landing check, examination of the aircraft showed that the undercarriage was fully retracted when the aircraft touched down. It was also found that the retraction and warning systems were fully serviceable at the time of the accident. It was apparent that the pilot was distracted by the prospect of a crosswind landing in gusty conditions and neglected to lower the undercarriage at the appropriate point in the circuit. Probably because he was using considerable power in the approach, the warning horn did not sound until the pilot closed the throttle as the aircraft was settling on to the ground.



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Arriving over a country aerodrome in Victoria at the conclusion of a charter flight, the pilot of a Cessna 320 decided to practise a "bad weather" type circuit. The pilot made a tight circuit at low level during which he went through the pre-landing drills by reference to a slide type checklist. When the pilot made his final power reduction just as the aircraft was about to touch down, the undercarriage warning horn blew but it was then too late to attempt to go around and the aircraft made a wheels-up landing.

Examination of the aircraft showed no evidence of any defects in the undercarriage retraction and warning systems. Although the pilot said that he had used the slide type checklist during the low level circuit, he admitted that he did not check the undercarriage warning lights. It is evident that he either forgot to lower the undercarriage or that when he went to select it, he did not move the undercarriage selector to the full down position. In this case also, the pilot was highly experienced both generally and on the type and had a total of 12,700 hours.

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At a country aerodrome in New South Wales, the pilot of a Departmental Cessna 310 was carrying out a series of circuits and landings. After selecting 15 degrees of flap towards the end of the downwind leg of one circuit, the pilot was in the process of selecting the undercarriage lever to the down position when the aircraft encountered a patch of turbulence. The pilot continued with his circuit, lowered full flap and approached for a normal touchdown, but the aircraft settled on to the runway on its fuselage with the undercarriage retracted.

When the aircraft was inspected after the accident, the undercarriage lever was found to be in the neutral position and subsequent tests established that the undercarriage retraction mechanism was capable of normal operation. It was evident that the pilot, after initiating the selection of the undercarriage lever to the down position, did not ensure that the undercarriage was extended before the aircraft landed. The pilot had a total of 12,000 hours' flying experience with more than one thousand on this type of aircraft.

These accidents, like the many others that have occurred in Australia and overseas, show conclusively that the potential for landing an aircraft with the undercarriage retracted is always present, no matter what the experience of the pilot. Indeed, it might even be possible that the old adage "familiarity breeds contempt" sometimes plays a part and that some very experienced pilots could perhaps be more susceptible to such lapses than pilots of lesser experience who, because of their comparative unfamiliarity with an aircraft, have a tendency to be more deliberate in their actions in the cockpit.

It is important to recognise that all human beings, no matter how competent they are at a given task, are subject to occasional, apparently inexplicable lapses. It is quite clear from the examples discussed, that wheels-up landing accidents of this type can only be avoided by constant and rigid adherence to prescribed checking procedures. It is worth remembering that these procedures have been evolved over the thirty-odd years that retractable undercarriage aircraft have been in service, that they directly reflect the lessons learned from retractable undercarriage accidents, and that their sole purpose is to prevent such accidents.

To deliberately short cut these procedures is to completely disregard the wealth of experience that has been accumulated in attempts to overcome the potential for human error inherent in retractable undercarriage systems. The accidents also show how foolish it is to render warning horns inoperative, as some pilots evidently do. Like the checking procedures already discussed, these audible warnings have been devised for the express purpose of avoiding accidents! A few minutes' reflection should be sufficient to see such "short cutting" practices for what they are—short cuts to accidents!

FILES

FROM THE INCIDENT

TOO CLOSE FOR COMFORT!

AT Port Moresby, Papua, a Cessna 182 was departing for a private flight to Kairuku. After taxi-ing to the holding point for the duty runway, the aircraft was seen running up in the normal way. The pilot then reported ready and the tower controller cleared it for take-off. The aircraft entered the runway and began what appeared to be a normal take-off, but on lifting off, it immediately assumed a steep nose-up attitude. The aircraft then turned sharply to the left and began a series of erratic climbs and descents. A few moments later, the pilot transmitted a Mayday call requesting a clearance to make an emergency landing on the duty runway.

The aircraft was cleared to land immediately, the crash alarm was sounded, and the fire crew turned out. Eventually, after making a wide circuit during which the aircraft continued to manoeuvre in an alarming, erratic manner, it was more or less lined up with the runway but appeared barely under control. About a third of the way down the runway, still airborne, control seemed to be regained and the aircraft touched down smoothly. A fire tender followed it as it rolled to a stop, and taxied to its parking area and shut down.

Shortly afterwards, the pilot telephoned the tower to explain his hair-raising experience. The report he wrote later speaks for itself:

" . . . I started up for a private flight to Kairuku with three passengers on board.

Receiving a taxi clearance from Port Moresby tower, we proceeded to the holding point for runway 14, where I commenced the run-up and pre-take-off checks, but forgot the last and most basic of all—checking that the controls were functioning normally!

We were cleared for take-off. With 20 degrees of flap selected, I lined up and opened the throttle. The aircraft became airborne at about 65 knots and immediately entered a very steep climb. Corrective action taken was to apply forward pressure to the control column but then I discovered that the controls were jamming. Fearing a full-power stall, I tried applying elevator trim, which relieved the situation temporarily. I was also worried that the starboard wing might drop, so I applied a little rudder to counteract this which consequently turned us to port. Then the nose dropped away, so the trim was used to correct it. I transmitted a "Mayday" call and requested an immediate landing on runway 14. With the aircraft pitching rather violently, I tried to keep it under control with the use of power and trim.

Because only the rudder controls were left, the turn on to final was very wide, and as a result I used up a lot of runway before finally lining up and landing. At first, I thought all this had been caused by a mechanical fault, but on taxi-ing in realised what I had done, or in this case had not done. The control column lock was still in place!"

Cessna pilots and operators, accustomed to the normal Cessna internal control lock, which incorporates a red metal "flag" to cover the master or magneto switches when in place, may wonder how a pilot could fail to notice that the control column lock had not been removed. So did our Inspector of Air Safety—until he found that the standard control lock was missing from this particular aircraft and that a small metal bolt was being used in its place! Even though a piece of red cloth had been attached to the bolt to make it more conspicuous, it still escaped the pilot's notice until, very relieved to be safely on the ground again, he was actually taxi-ing in!

Although this fact does not excuse the pilot's gross omission in forgetting to check the controls for freedom of movement before taking off, it is abundantly clear that the operators of the aircraft, by allowing such an unlikely and obscure type of "control lock" to be used at all, had set the stage for a very serious and probably fatal accident. The fact that such an accident was finally averted in this case was due only to the pilot's presence of mind and his skilful handling of the aircraft, in combination with reasonably smooth flying conditions and, no doubt, a large measure of what we can only call luck!

Accidents in which pilots have been deprived of control after take-off by locks unintentionally left in place have occurred all too frequently throughout the history of heavier-than-air flight. Nearly always the results have been catastrophic. Spared the fate that has befallen so many others in a like predicament, the pilot of the Cessna has no doubt learnt a lesson he will remember for the rest of his life. But all of us who share his experience through the pages of the Digest—pilots, engineers, operators and owners—can also profit by it. We can resolve never to condone any makeshift operating practice, such as the one that contributed to this incident, that could conceivably become a link in a chain of events leading to an accident.

ARE YOUR SEATS SECURE?

AT Darwin, Northern Territory, a flying instructor was being given a periodic flight check by her chief flying instructor, in a Cessna 172. Returning to the circuit area, the chief flying instructor, occupying the right hand seat, indicated he would take over, and he slid his seat into the fully forward position to do so.

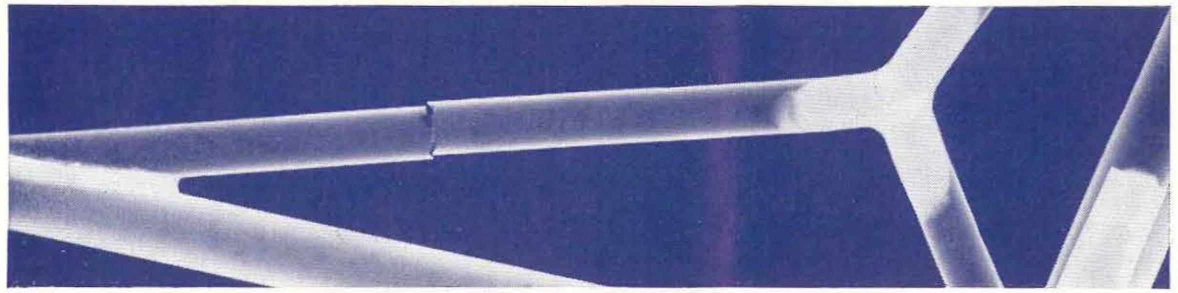
Taking hold of the controls, the chief flying instructor relaxed back in his seat, but immediately it unexpectedly fell backwards, and he was half-somersaulted into the rear seat compartment. The effect of the sudden backward pressure which the chief flying instructor involuntarily applied to the control wheel, combined with the rapid change in centre of gravity position, caused the aircraft to nose-up violently. To make things more difficult for the pilot in the left-hand seat, who immediately tried to regain control, the senior instructor's feet became hooked beneath the lower rim of the control wheel. Although the pilot in the left-hand seat recovered control very quickly in the circumstances, considerable height was lost before she could do so.

It was subsequently learned that a week beforehand, another pilot had removed the seat while the aircraft was used for parachute jumping, and that when he replaced it, he omitted to reposition the forward seat rail stops. Thus, when the chief flying instructor moved his seat forward in flight, the front leg runners slid off the front end of the seat rails. Restrained then only by the rear leg runners, the seat slid back on the rails and tipped over backwards until it came to rest against the cushion of the aircraft's back seat. Although the pilot who removed the seat was properly authorised to do so, he had entered no details of its removal and replacement in the aircraft's Maintenance Release. As a result, the seat's installation was not checked by the operator's maintenance staff.

This incident is similar to one reported in the Digest two years ago, when an Examiner of Airmen, preparing to conduct an instrument rating check, suffered a similar experience in the right-hand seat of a Cessna 411. In this case also, the seat had been removed previously and was not properly replaced.

The two cases show that there is a potential for incidents of this sort whenever a seat is removed and replaced in an aircraft. Fortunately in both these instances that have came to notice, experienced pilots have been occupying the left-hand seat, and in one case the aircraft was still safely on the ground. But what might the consequences have been if the pilot in the left-hand seat was an inexperienced student and the instructor's seat had failed at a critical stage of flight—for example (as would be quite likely) immediately after take-off? It is well to remember too, that even a seat adjustment which is not properly latched, could produce consequences very similar in outcome.

FAILURE OBSCURED . . .



RECENTLY, while a routine X-ray inspection was being performed on the engine mounting structure of a certain light twin-engined aircraft for the purpose of determining whether or not corrosion was present on the internal surfaces of the welded tubular structure, it was noticed that about three inches of the diagonal bracing tube in the bottom panel was wrapped with friction tape. The area with which the inspection was concerned is shown within the dotted lines of Figure 1. When the X-ray film was developed, the photograph showed that the bracing tube was fractured at a point within the section covered by the tape (see title illustration). The broken section was cut out and examined to determine the cause of failure.

It was found that the tube had been very badly chafed by a flexible pipe line resting against it, without the pipe having been properly supported or the tube protected against damage. Figure 2 shows the extent to which the chafing had reduced the thickness of the tube wall before it failed as a result of fatigue. It was evident from the indentations shown in Figure 3 that the aircraft had been flown for some considerable time after the fracture had occurred. The indentations were caused by the hammering of the broken ends of the tube and their extent gives a clear indication of the degree of distortion that occurred in the engine mount after the bracing tube broke.

Consideration of the effects of this distortion shows that the engine mounting had become unstable and as a result, the remainder of the engine mounting tubes were carrying loads for which they were not intended to carry. Continued operation of the aircraft with the engine mounting in this condition would have eventually induced early, and possibly catastrophic failure of the whole structure.

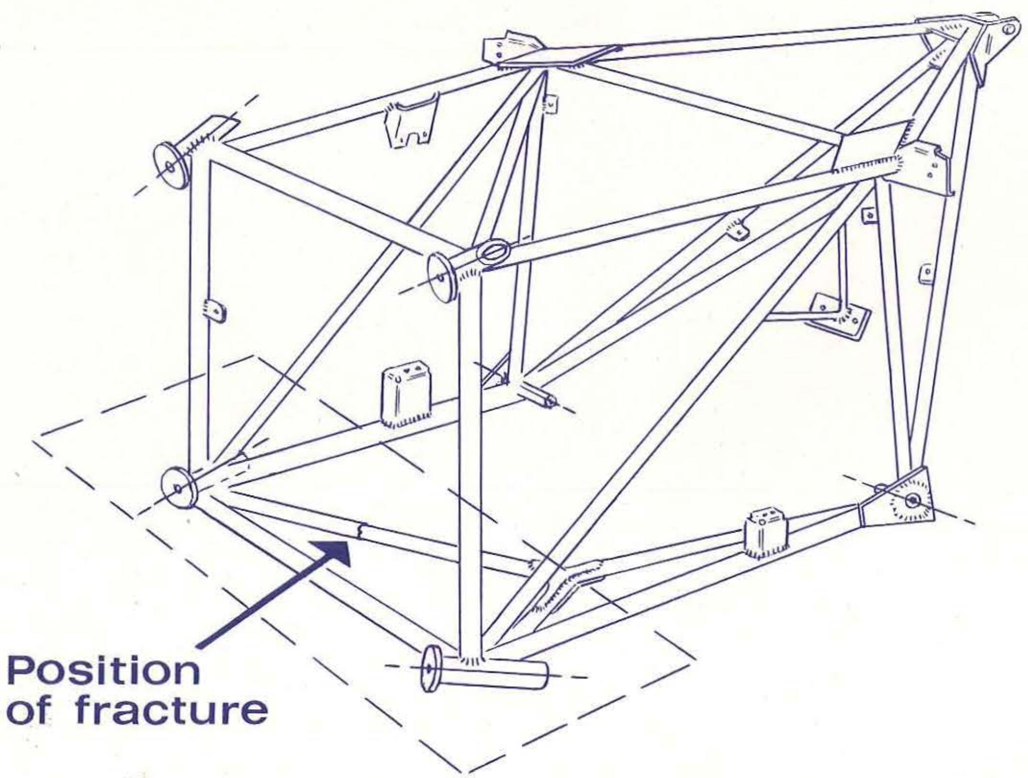


Fig. 1. Three-dimensional drawing of engine mounting, showing position of fracture.

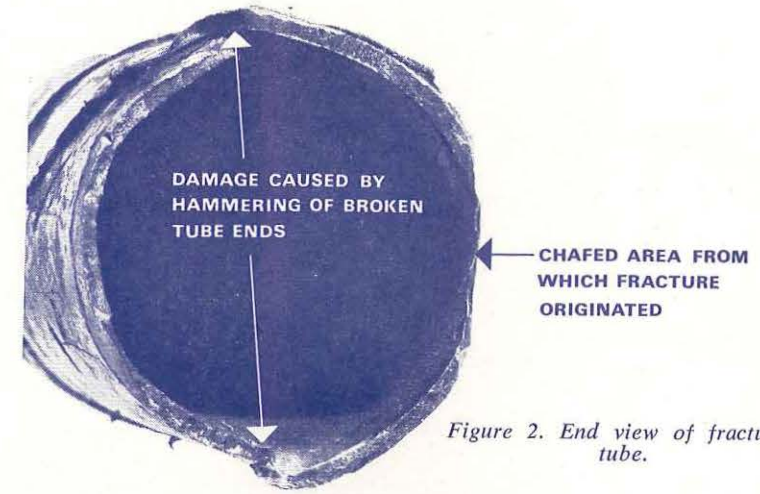


Figure 2. End view of fractured tube.

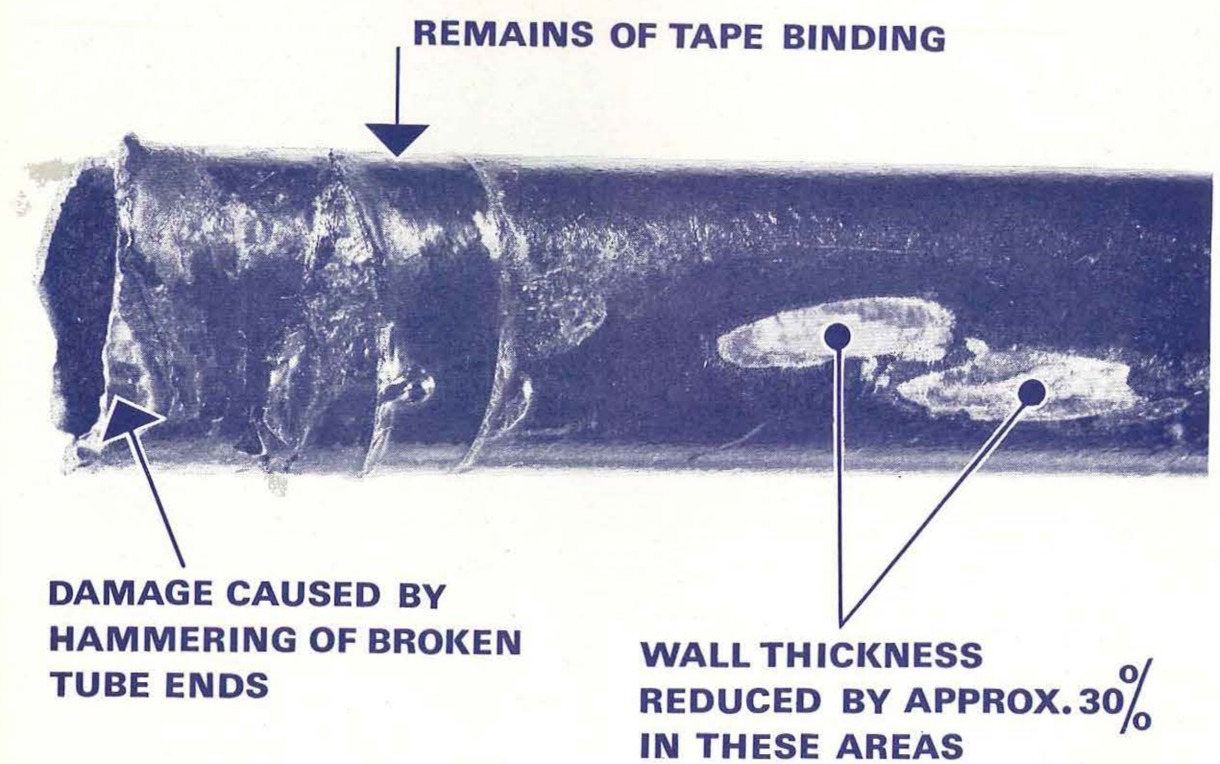


Figure 3. Side view of fractured tube.

It is evident from the presence of the tape binding on the tube that someone had seen the chafed area and had applied the tape to prevent further damage. Whilst this may have been done in good faith, the person concerned was actually covering up a serious defect, because the damage had obviously progressed to the extent that a repair was necessary even at that early stage.

Figure 3 shows what the chafed area probably looked like when the tape was applied. This is believed to be so because, at the time that the X-ray inspection was performed, the tape had not been penetrated. Two other chafed areas can also be seen, both of which had reduced the thickness of the tube wall by about 30 per cent. In all probability, these two areas would have become starting points for failures similar to the one that actually occurred.

Although it is accepted practice for structures to be protected against the chafing by the use of tape binding, such precautions are not really effective unless the fuel line or similar item is secured to the structure in such a way that relative movement between the two items is prevented. Under no circumstances however, should tape binding be applied to components or structure in which damage is already evident. The circumstances which caused the failure under discussion reflect a very low standard of technical competence, firstly in continuing to accept an installation which allowed the chafing to occur, and secondly in obscuring a defect of such a serious nature.

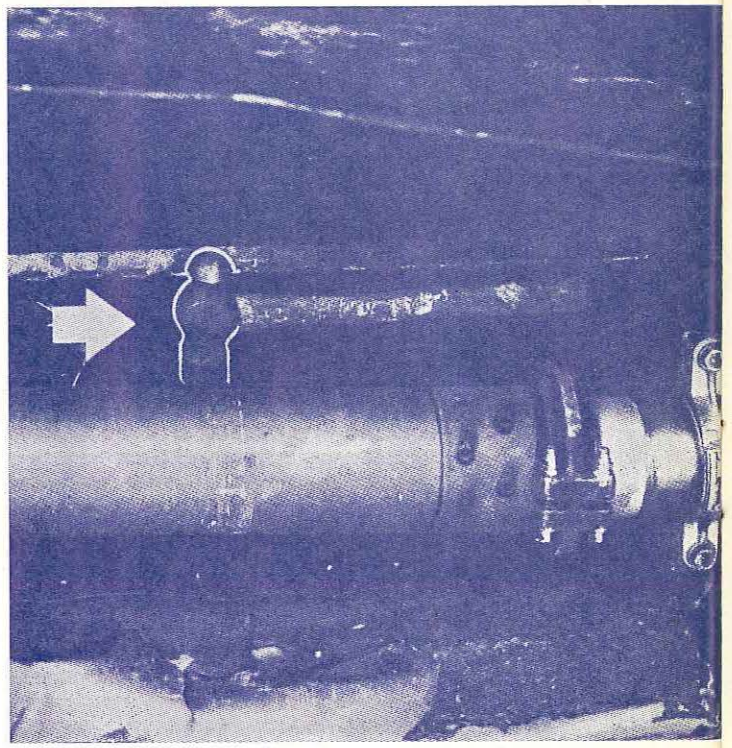
A fact that is not always fully appreciated about metal structures is that scratches, dents and other surface irregularities cause a reduction in fatigue life far in excess of the apparent physical damage. This should always be borne in mind, particularly when installing components which may subsequently be difficult to inspect in an assembled aircraft.

Forgotten Tools - - - - -

THE Digest has on many occasions emphasised the dangers that forgotten tools can pose if they happen to be left inside the structures of aircraft at the completion of maintenance work. A recent fatal accident to a military helicopter in the United States provides a grim reminder of just how vital it is for maintenance engineers to account for all their equipment while cleaning up at the conclusion of a job.

With a crew of four and two passengers on board, a Bell 205 began a 20 degree bank to the left at 85 knots. While in the turn, the tail rotor failed. The airspeed dropped to 40 knots, the aircraft spun to the right, crashed to the ground in a level attitude and burst into flames before rolling on to its port side. Two of the crew and the two passengers were killed. Of the other two members of the crew, one escaped with serious burns and the other with minor injuries.

It was found that the tail rotor drive shaft had failed in flight. The failure was caused by an engineer's hammer which had been left inside the tail rotor shaft cover (see photograph), in the course of a daily inspection. The inspection had been carried out at night in the open with only the aid of a torch.



MUSIC WHEREVER HE GOES!

TO open the hopper lid of a certain type of high-winged agricultural aircraft, the pilot pulls down on a cable leading through the cockpit roof. When he opens the throttle to take off after the hopper has been loaded, the slipstream closes the lid and the toggle handle on the end of the cable is drawn back into position, close to the roof of the cockpit.

Engaged on spreading operations, the pilot of one such aircraft had just taken on another load of superphosphate. He released the toggle handle, opened the throttle and began to take off. For some reason, the aircraft's acceleration was abnormally slow and, as he approached the end of the strip, still earth-bound, the pilot decided he'd better dump his load. The aircraft staggered into the air, but not early enough to prevent the port landing wheel hitting a large stump. Once airborne, the aircraft began to judder alarmingly and the pilot realised there was something seriously amiss with its performance, though the engine indications seemed perfectly normal. The pilot went around and landed again, but when the port wheel made contact with the ground, the damaged undercarriage leg partially collapsed and the aircraft swung to the left and came to rest standing on its nose. The pilot clambered down from the cockpit unhurt to find the reason for the lack of performance very obvious—the cable was still holding the hopper lid open in the vertical position!

It turned out that this particular pilot (let us call him Pilot Jimmy), was something of a rhythm fan and liked to dust crops to the beat of the current pop exponents. To make this possible he had gone to the trouble of fitting some bracketry in the cockpit, on the forward face of the hopper, next to his head. In the said bracket he carried his transistor radio! What more need be said? . . . when he released the hopper toggle, it of course jammed behind the bracket and prevented the hopper lid closing!

One might have thought better of Pilot Jimmy. As a professional pilot, he ought to have known that modifications to aircraft must be properly designed, approved by the Department and carried out by an appropriately qualified person. At any rate he has now learned that non-compliance with this requirement is not only illegal—it can also be very expensive!

Pilot Contribution

Remember this one?

— this pilot didn't and almost became another victim of Jack Frost!

EARLY in the morning, at an agricultural strip in Western Australia, the pilot of a Piper Pawnee had just taken on 80 gallons of spray mixture for his first flight of the day. The pilot continues the story himself:—

"Weather conditions were fine with no cloud or wind, and the aircraft's outside air temperature gauge was reading 30°F. A heavy frost lay on the ground and the aircraft's wings were covered by a layer of frost and ice. After carrying out a daily inspection, warming up the engine and running up, during which I checked for carburettor ice, I commenced to take off into the west. The take-off run seemed normal enough at first. Although the aircraft did not lift off where I would normally expect, I was not greatly concerned because I knew the frost on the wings would be affecting their aerodynamic efficiency. It was for this reason that I took on only a light load for this first operational sortie of the day.

As the take-off progressed, and the lift-off point that I had nominated approached, I eased the aircraft into the air. But once airborne, the aircraft failed to gain further speed and I was unable to climb out of ground effect. Although I now realised that the aircraft was not going to perform as well as I had expected, I could not abandon the take-off—the fence at the end of the strip was now too close to do so without damaging the aircraft. I tried dumping the load and climbing the aircraft simultaneously. This was only partly successful for, although the aircraft climbed sufficiently to clear the fence, it immediately mushed down again on the other side, allowing the tail wheel to contact the ground. I found I could not dump the load at first because the spraying control lever would not move past the spraying setting in to the dump position. After the tail wheel hit the ground, I managed to keep the aircraft airborne in ground effect, until I was able to force the lever into the dump position.

By this time, the aircraft was approaching a second fence, so again I tried to dump and climb simultaneously. But again I was only partly successful, for although the dump mechanism worked this time, the ground was rising slightly and the aircraft hadn't sufficient speed to climb. As the aircraft crossed the fence, the tail wheel hooked on the top wire and dragged it about 50 yards into the paddock beyond, before it snapped.

As this paddock was under crop, I was loath to continue dumping in it and as it looked smooth and firm, I closed the dump mechanism, cut the power and landed straight ahead. After the aircraft had rolled to a stop, I shut down the engine and climbed out to check for damage. I found the aircraft had sustained no damage at all, but two steel fence posts had been bent about 30 degrees and, as I already knew, the top strand of wire in the fence had been broken. After waiting for about an hour for the sun to melt the frost and ice off the aircraft, I taxied the aircraft across the paddock to the next fence, checking it for suitability as I went. It was suitable and, as the hopper still had 40 gallons of spraying mixture in it, I took off and commenced spraying.

It is worth noting that on subsequent loads of 110 gallons, with the weather conditions remaining much the same, the aircraft cleared the boundary fence by about 70 feet."

Comment

It is very much to the credit of the pilot involved in this incident that he submitted this comprehensive report against himself, in order that others might benefit from his experience.

We have no wish to appear hard on a pilot who has admitted his error so frankly in the interests of air safety, but to put the matter in perspective, we must say that we were more than a little surprised to learn that an experienced agricultural pilot, with nearly 4,500 hours flying behind him, could so lightly regard the danger that frost on the lifting surfaces of an aircraft can pose. It is clear that the pilot had neither absorbed the sound advice on the subject in the "Pilot Technique" section of the Agricultural Pilot Manual (OPS 3.1), nor paid much attention to the warnings that have appeared in the Digest from time to time (see Aviation Safety Digests Nos. 46 and 51, in addition to No. 56 from which the illustration above was reproduced). Had he done so, the pilot would have been much more wary of the fact that his aircraft had been standing overnight in the open in cold weather!

As pointed out in one of the earlier articles in the Digest, a coating of frost on the wings of an aeroplane, though it hardly affects the aerofoil shape in the way that ice picked up while flying in cloud does, produces a very rough surface. This increases drag and destroys the smooth flow of air over the aerofoil, thereby promoting early airflow separation and raising the stalling speed.

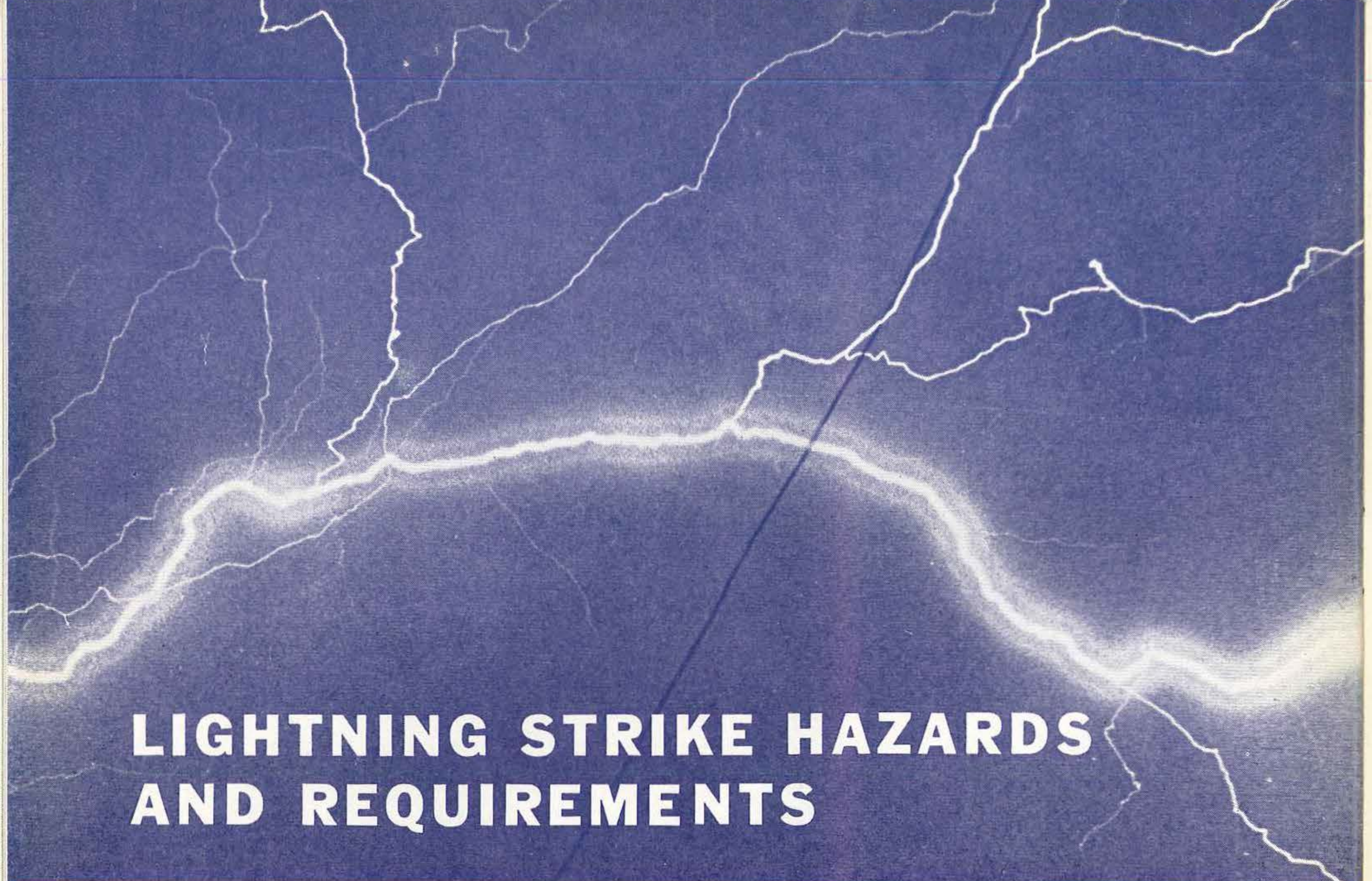
Good airmanship dictates that frost should always be hosed or rubbed off an aircraft before a take-off is attempted!

BEWARE THE HIGH WIRE!

While "cleaning up" a small section of paddock at the conclusion of a super spreading operation in hilly country near Wodonga, Victoria, the pilot of a Pawnee descended a little lower than usual to position the super accurately in the remaining area. As he did so, he failed to notice a single wire power line in his path and the aircraft flew into it. The wire, which ran from the top of one ridge to another across the shallow valley in which the field was situated, was higher than usual in the spreading area. Fortunately, the propeller cut through the wire and damage to the aircraft was confined to a dent in the spinner.

As the pilot pointed out in his report, the incident provides a sharp reminder that top dressing operations in hilly country can easily become a trap for the unwary. Wires at considerable heights are not unusual in such terrain and the hazards they pose are becoming more widespread each year as electricity schemes are extended further into country areas.

The only safeguards are proper preliminary inspections, careful planning and undiverted attention to the positions of the wires during each and every spreading run. It is significant that in this case, the pilot was familiar with the area, having operated there on previous occasions, and knew that the wire existed.



LIGHTNING STRIKE HAZARDS AND REQUIREMENTS

The following article discussing the possible effects of lightning strikes on aircraft is adapted, with acknowledgement, from the British European Airways publication "Air Safety Review". The article is based on a paper prepared by Mr. B. L. Perry of the Air Registration Board in the United Kingdom.

Although more concerned with the airworthiness considerations of lightning strikes, rather than being strictly in the field of air safety education, the article contains much that will be of interest to the airline industry in Australia. It is being reproduced in the Digest to ensure that pilots and engineers have the opportunity of studying this latest contribution to the little known subject of lightning strikes on aircraft.

FOR centuries the damage caused to buildings and other objects on the ground has been well documented and over the years, methods of protection for such buildings have been evolved and developed. With aircraft however, the rate of development has been such that the time available to solve problems has been much less and the rapid growth of airline operations in all parts of the world and under all climatic conditions has meant that more and more aircraft are being exposed to the effects of lightning strikes.

In the late 1950s it was realised within the Air Registration Board that the requirements for the protection of aircraft against damage, and possible disaster, were not adequate. This view was confirmed by several cases of severe damage caused to aircraft which were inadequately protected.

A study of the data available at that time showed the dearth of detailed information on the incidence and effect of lightning strikes on aircraft. The limited military and civil records available suffered, in the case of the military information, from difficulties regarding security and comparatively limited flying hours, and the civil data tended to be made available via the aircraft constructors and was thus second or third hand before its presentation, and consequently suffered in completeness and accuracy.

With the co-operation of several British airlines, a reporting system was introduced whereby details of all lightning strikes to their aircraft were recorded. It is the object of this paper to summarise and present the data gathered by these records and to outline the requirements for the protection of British civil aircraft, based on these records and other available information.

Type of Aircraft	Zone of Operation	Period Covered	No. of Strikes	Total Flying Hours	Incidence of Strikes
Viscount	Europe	March 1959 to June 1964	195	567000	1/2900 hrs
Vanguard	Europe	May 1961 to June 1966	79	194000	1/2500 hrs
Comet 4B	Europe	June 1960 to June 1966	86	162000	1/1900 hrs
Trident	Europe	May 1964 to June 1968	92	140000	1/1400 hrs
Britannia	Europe	October 1959 to April 1961	6	115000	1/19000 hrs
Boeing 707	World-Wide	January 1962 to December 1967	103	458000	1/4400 hrs
VC 10	World-Wide	August 1964 to May 1968	28	251000	1/9000 hrs
Total	Europe	-	452	1063000	1/2400 hrs
Total	World-Wide	-	137	824000	1/6000 hrs
Total	Europe and World-Wide	-	589	1887000	1/3200 hrs

Table 1—Incidence of Lightning Strikes Relative to Aircraft Type, Zone of Operation and Flying Hours.

Analysis of Lightning Strikes

The airlines concerned recorded the position and type of damage of strikes, in addition to the aircraft's altitude, outside air temperature, and weather conditions. These records have been kept for varying periods, from 1959 to date, for Viscount, Vanguard, Comet 4B, Trident, Britannia, Boeing 707 and VC.10 aircraft.

Table 1 shows that the average incidence rate, for aircraft operating in Europe, is one strike per 2,400 flying hours. The rate, in world-wide operation, is somewhat lower at one strike per 6,000 flying hours. Since the reports of world-wide operators do not show any more strikes occurring to their aircraft in Europe, as compared with the rest of the world, it can be assumed that the difference between European and world-wide incidence rates is a function of the percentage of the flying time spent at lower altitudes, which as will be shown later, presents the highest risk.

If one assumes a flying rate of 6¼ hours per day, then the European figures show that each aircraft will be struck, on the average, once per year; at 10 hours per day each aircraft will be struck, on the average, once every eight months. For world-wide operations, while the incidence of strikes per flying hour is lower, the incidence of strikes per flight is similar to that in Europe.

Figures 1 and 2 show the percentage of strikes relative to outside air temperature and altitude respectively and provides meteorological information regarding the most probable temperatures and altitudes for thunderstorms. It is worth noting that several strikes were recorded at altitudes over 20,000 feet and up to 30,000 feet.

Figure 3 shows, for aircraft operating in Europe, the most probable months of the year for strikes. These percentages have not been corrected to allow for the increased flying hours of the aircraft during the summer months but this correction, if made, does not materially affect the overall pattern. This data therefore also supplies approximate meterological information on thunderstorm activity over the year.

Consider now the damage caused to the aircraft by these strikes. This is summarised in Table 2 as a total of 456 strikes on six different aircraft types. Under the heading 'hole in structure or radome', are included all cases of actual penetration of the skin or puncturing of the radome.

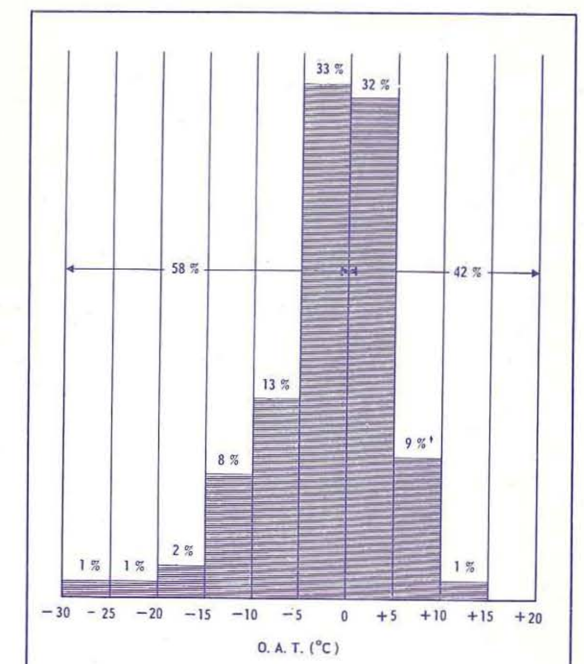


Figure 1. Distribution of lightning strikes relative to temperature—Viscount, Vanguard and Comet aircraft.

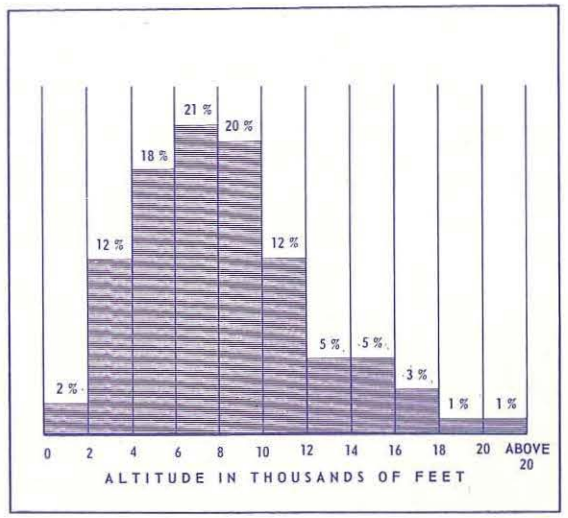


Figure 2. Distribution of lightning strikes relative to altitude—Viscount, Vanguard, Comet, Trident, VC10 and Boeing 707 aircraft.

'Slight damage' covers burns and scorch marks; rivet heads in particular were noted as being particularly susceptible to this type of damage.

A detailed study of the actual positions of damage caused by the entry or exit of a strike shows that the portions affected have been the nose and fuselage, wing tips, the trailing edges of the ailerons, flaps rudder and elevator, the tips of the fin, tailplane and tail cone, and the antenna and static wicks. As can be seen from Table 3, swept wing aircraft, by comparison with straight wing aircraft, appear to be more liable to strikes, along their main axis, from nose to tail, than to strikes on the wings.

Study of the reports for any other effects of the lightning strikes showed that damage to antenna was confined mostly to HF aerials and their associated aerial tuning units. Even when antenna had been struck directly, as shown by burn marks, the associated radio equipment was rarely affected. As would be expected, the static wicks on all types of aircraft were regularly damaged or destroyed. Compasses, both remote and direct magnetic, were affected in some cases. This was particularly so on one type of aircraft where, in approximately 20 per cent of all reported strikes, the direct reading magnetic compass was found to have a large error after the incident, indicating the presence of 'soft iron' adjacent to the instrument.

Type of Aircraft	Period Covered	No. of Strikes	Damage Caused: Hole in Structure or Radome %	Damage Caused: Slight Damage %	Damage Caused: No Damage %
Viscount	May 1961 to June 1964	92	39	42	19
Vanguard	May 1961 to June 1966	79	30	52	18
Comet 4B	May 1961 to June 1966	72	35	25	40
Trident	May 1964 to June 1968	90	11	57	32
Boeing 707	January 1962 to December 1967	96	17	50	33
VC 10	August 1964 to May 1968	27	30	44	26
Total	-	456	27	45	28

Table 2 — Damage Caused to Aircraft by Lightning Strikes Relative to Aircraft Type.

No physiological effects on the aircrew have been reported in any of these cases, even when strikes to the nose and windscreen pillars have occurred.

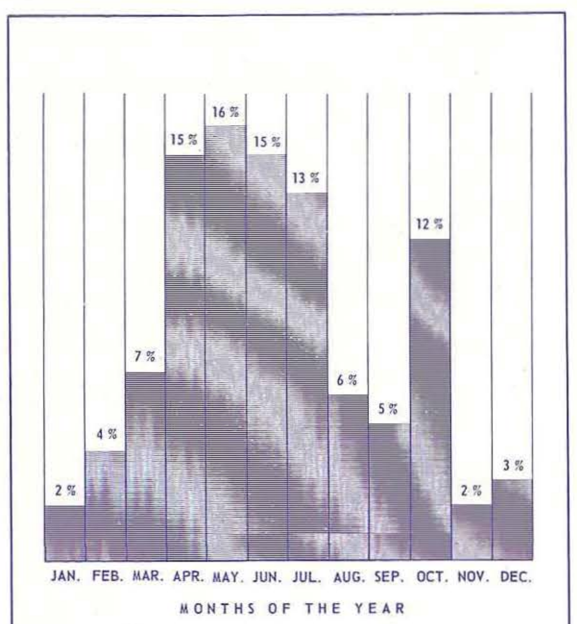


Figure 3. Occurrence of lighting strikes in Europe, relative to months of year — Viscount, Vanguard, Comet and Trident aircraft.

Hazardous Effects of Lightning Strikes

Having shown above that the incidence of strikes on aircraft in civil operation is of the order of one strike per aircraft per year, it is obviously vital, from a safety point of view, that these strikes do not hazard the aircraft or its occupants. The potential risks are considered under four headings, namely, Structural, Fuel, Other Systems and Personnel. These are inter-related but are considered separately below and some of the possible effects are reviewed and illustrated.

Type of Aircraft	General Area Struck: Axial - Nose, Fuselage, Tail End, including Fin, Rudder and Elevators % of Total Recorded Damage	General Area Struck: Transverse - Wing Area including Propellers, Nacelles, Flaps and Ailerons % of Total Recorded Damage
Viscount	65	35
Vanguard	77	23
Comet	80	20
Trident	75	20
Britannia	64	34
Boeing 707	75	25
VC 10	80	20
Total 'Straight Wing'	69	31
Total 'Swept Wing'	78	22

Table 3—Positions of Lightning Strikes on Aircraft Relative to Aircraft Type.

Structural Effects

The nose of an Ambassador aircraft, of wooden construction, was so damaged and displaced by a lightning strike, that the view through the windscreen was obstructed. The aircraft however, was landed safely, by the second pilot who was able to see through the direct vision window. Such materials are now not normally used in the construction of civil aircraft but this illustration does show how structural damage can cause danger to an aircraft. Similar dangers can arise if portions of the airframe are damaged and blown into flying control surfaces or propellers, or ingested into the engines.

Such disruption of structure can be caused by the rapid expansion of gases within the materials themselves, or by the rapid build up of pressure within enclosures covered by the parts struck by lightning, causing damage to the parts themselves or the surrounding structure. Because of the increasing use of fibre glass for aircraft structural purposes, this danger must be fully recognised.

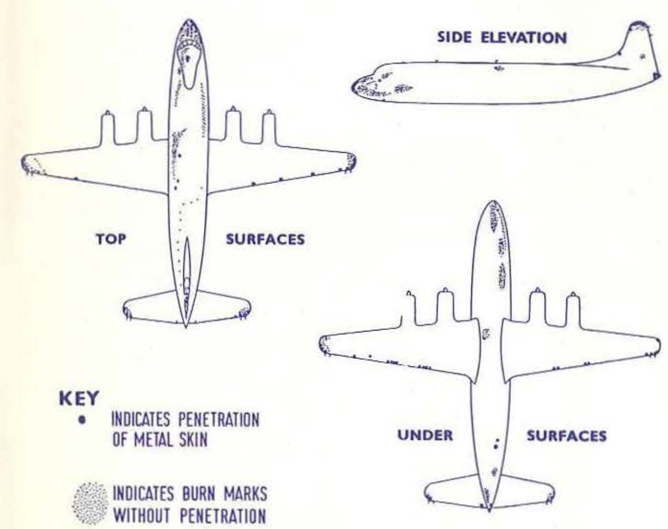


Figure 4. Position of lightning strikes on Viscount aircraft. March 1959 to June 1964.

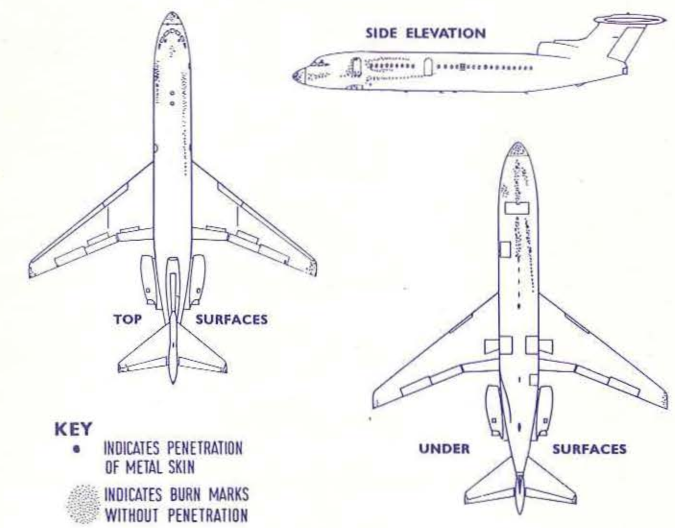


Figure 5. Position of lightning strikes on Trident aircraft. May 1964 to June 1968.

With high speed aircraft, the effect of holes or structural damage which may occur, unnoticed, during the early stages of a flight, must be considered relative to the performance and handling of the aircraft during later, possibly supersonic, stages of the flight.

The above study of actual strikes shows that a fair proportion of strikes entered or left the aircraft at the trailing edges of the flying control surfaces. Thus, high currents must have passed across the hinge points of these surfaces. In some aircraft, flexible conductors of sufficient size to carry these currents are connected across the bearings. This may not be essential however, since tests carried out in England with peak currents of up to 100,000 amps through various bearings down to

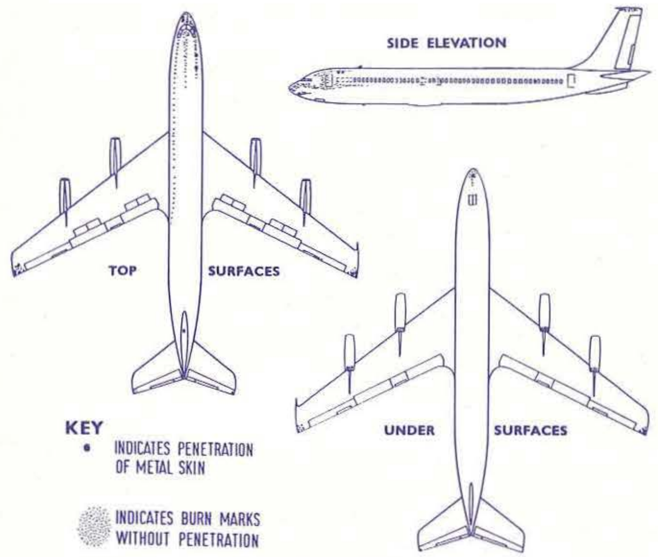


Figure 6. Position of lightning strikes on Boeing 707 aircraft, 1962 to 1967.

three-quarters of an inch outside diameter showed slight damage to the bearings but no cases of bearing seizure. This is supported by actual aircraft experience. While cases of damage to bearings have been reported, the writer has no knowledge of actual seizure of a control surface bearing due to a lightning strike.

The need to provide a path not only of low resistance but also of low impedance is illustrated by the damage caused to the seals of the hydraulic jack operating the control surfaces on the tail of a T-tailed aircraft. The jack was shunted by a conductor of adequate cross-section to carry lightning strike currents, but due to difficulties in the physical installation, this conductor ran in a fairly large loop. In service, strikes to the tail caused current to flow, not through this conductor, but through the jack body, and across the seals, resulting in a leakage of hydraulic fluid.

Fuel Hazards

The dangers of igniting fuel vapour in the aircraft fuel system vents are well known and it is encouraging to note the large amount of investigation which has been undertaken on this problem. The importance of locating these vents, and the fuel jettison pipes, away from likely strike areas cannot however, be over-emphasised.

The incidence of strike damage to aircraft wing tips confirms the potential danger when wing tip fuel tanks are fitted. These are exposed to the full energy of direct strikes and, if of metallic construction, must have adequate skin thickness to prevent penetration or, if non-metallic, must be protected with a suitable conducting cage. Many cases have been reported of military aircraft sustaining damage to wing tip tanks.

Little evidence is available of damage to aircraft wing surfaces where skin penetration has resulted, and caused a potential hazard to integral fuel tanks. This problem, and the dangers of semi-insulated access panels into such tanks, will however be considered later.

While experience to date has shown no problems in the electrical circuits of fuel tank mounted equipment, due to direct or induced currents caused by lightning strikes, this potential danger must be kept in mind during the design of aircraft and the location of cable runs in the wing areas.

Damage to Other Aircraft Systems

The items most susceptible to direct damage from lightning strikes are external protruberances such as antennae. Apart from HF aerials which, as discussed earlier, have sustained considerable damage, this survey indicates that the present designs of aerials do provide an adequate level of protection against damage to associated radio equipment.

Damage to electrical cables, due to the passage of lightning currents, occurred when the aircraft concerned was struck at the navigation light on one fibre-glass wing tip. The tip exploded and was lost completely, resulting in damage to the adjacent wing ribs. The trailing edges of both ailerons were badly burnt and all the static wicks on the aircraft were damaged. The strike current apparently entered the aircraft's electrical system by way of the navigation light, causing overheating of wiring throughout the aircraft, particularly at the wing root and behind the pilot's instrument panel. The remaining navigation light bulbs all exploded with considerable force, and the heater igniter coil, stall warning horn, and flap motor were all burnt out. One can only speculate as to what the effect would have been of such an occurrence to an aircraft fitted with semi-conductor equipment.

The possibility of damage on other externally mounted items such as pitot-static heads, stall warning vanes, etc., must be remembered, not only because of the mechanical damage caused by a direct strike, but also because such items may provide, via the heater wires for example, a passage for the strike into the aircraft's electrical system.

Several such cases have been recorded but adequate means of protection are available.

Personnel Risks

None of the reports covering the 600 strikes tabulated above made mention of any injury to aircrew. It has however been reported that, in two cases of lightning strikes to a Viscount aircraft, 'both pilots were blinded for 5 to 15 seconds, and were partially incapacitated for several minutes.'

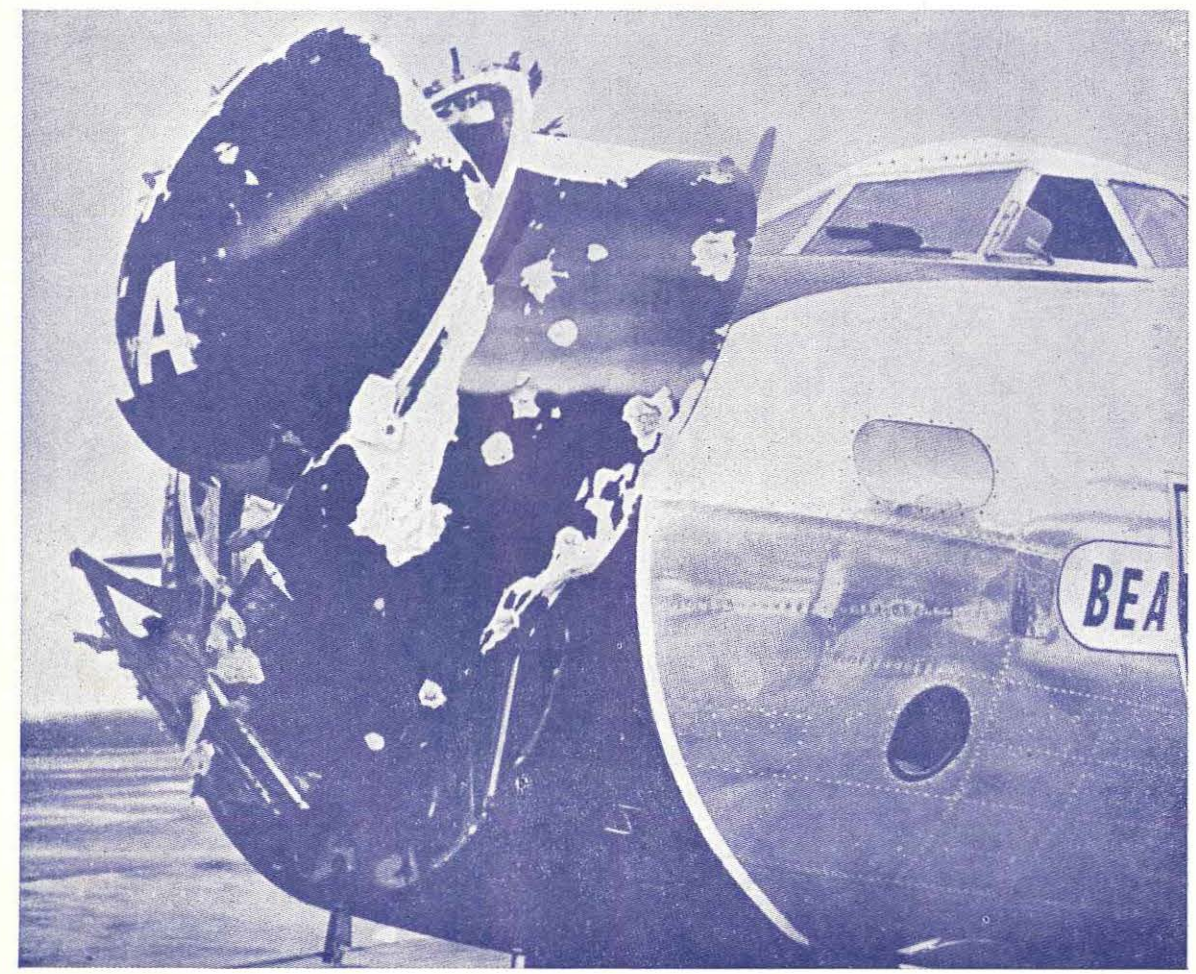
Requirements and Recommendations

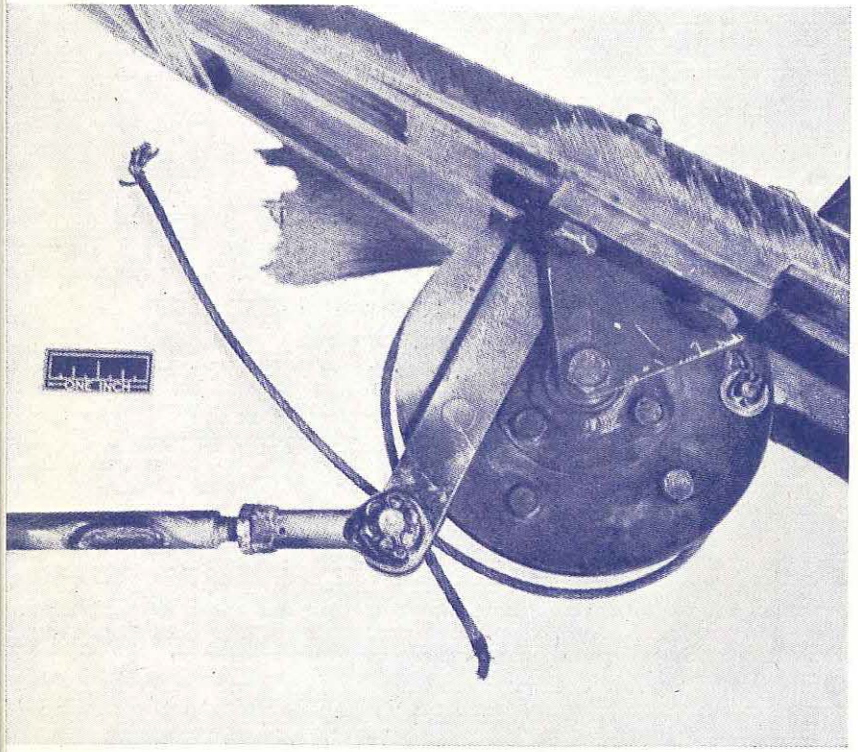
In 1963, following a study of the airline reports received, and a detailed review of all other available data, the requirements for the protection of British Civil Aircraft against lighting strikes were completely rewritten and published in British Civil Airworthiness Requirements. More recently, a further review of the latest information has been made and this is taken into account in the Anglo-French Supersonic Transport Aircraft TSS Standard No. 56. While this TSS Standard is specifically a requirement for supersonic aircraft, it does in fact cover the most recent thinking in Britain for the protection of civil aircraft in general. The TSS Standard incorporates the requirements of Chapter D4-6 of BCAR, and also takes into account the recommendations of an FAA Advisory Circular on this subject.

Conclusions

The first section of this paper shows quite clearly that civil aircraft are regularly struck by lightning

Damage caused to an Ambassador aircraft by a lightning strike on the nose cone.





Effect of lightning strike currents flowing through the aileron cables of a glider of wooden construction.

and it is to be expected that this will continue at approximately the present rate. It appears most improbable that any major advance in, say, weather radar, will allow the complete avoidance of thunderstorm activity, and even if this were so, the necessary flying restrictions would, most probably, be commercially unacceptable.

Although the present British accident record relative to the number of strikes is good, this must not lead to complacency regarding the design of future aircraft. Two of the examples quoted above show how near aircraft damage has been to causing a disaster. More work is required to find answers to the many unknowns, both of the nature of lightning strikes, and their effect on aircraft and their systems.

The responsibility to provide a safe aircraft rests with the aircraft designers. The dangers which can arise from lightning strikes must be kept in mind by those concerned with all aspects of aircraft design, particularly by structural and fuel system engineers as well as the electrical and radio specialists. Protection can, if considered early enough in the design, be built in, at little or no penalty in weight and cost. Equally, it is the responsibility of those of us concerned with airworthiness aspects to ensure that adequate standards are maintained and that these standards are both realistic and up-to-date.

The wrong knob!

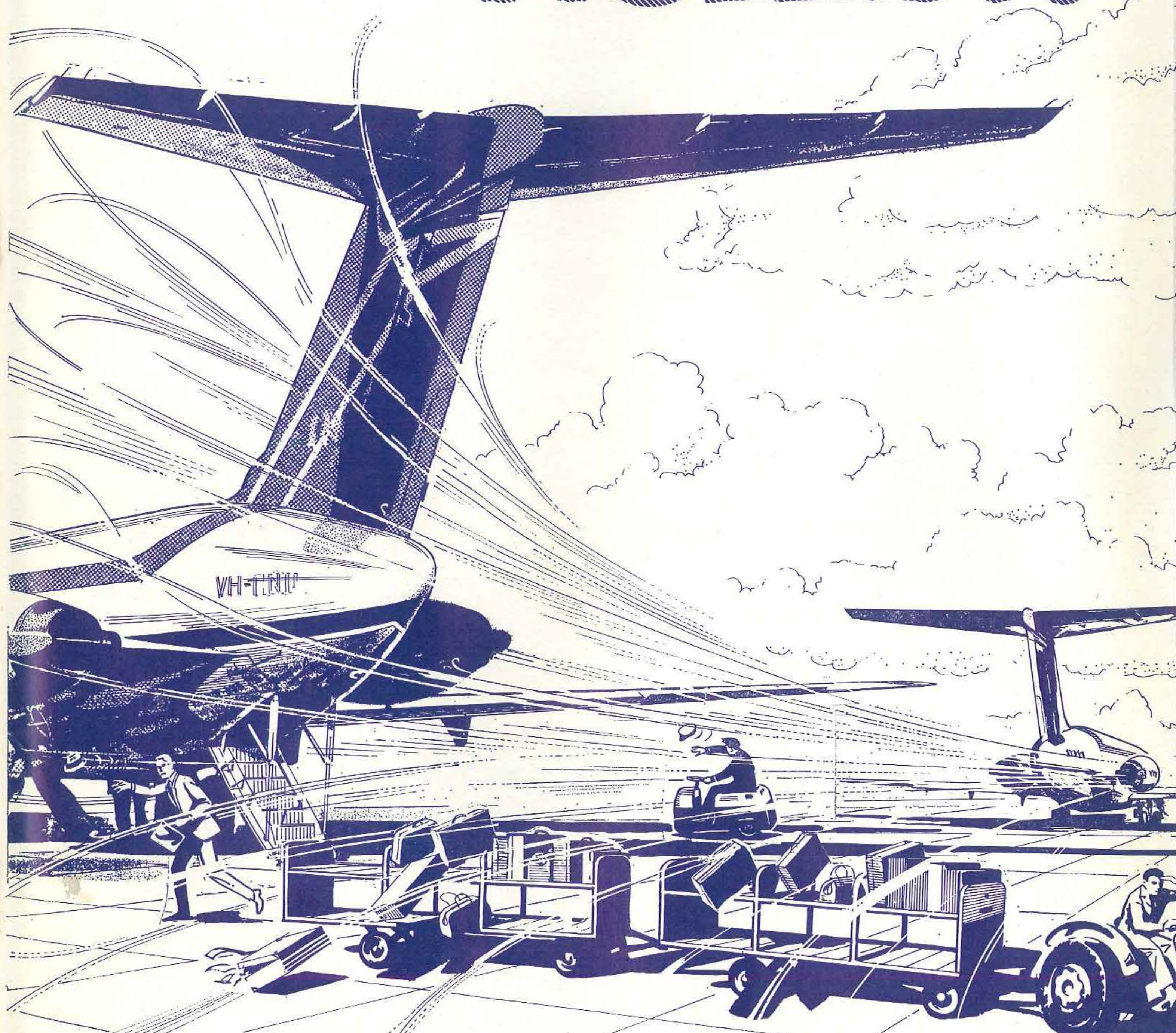
With a pilot and two passengers on board, a Hughes 269B helicopter was engaged on a photographic flight over St. Helens Island, Canada, the site of the Canadian Expo 67. The weather at the time was fine and clear.

While flying over the site at 300 feet, the pilot went to apply cabin heat but in error selected the mixture control to the idle cut off position. The engine failed and the pilot began an autorotational approach towards the closest shore line to try and avoid works in progress on the ground. The helicopter's angle of descent, however, was towards a congested roadway so the pilot applied collective pitch to try and avoid the area. This resulted in a loss of rotor r.p.m. and the helicopter fell heavily on to rocky ground near the shore line. The pilot and one of the passengers were seriously injured and the helicopter was substantially damaged.

On this type of helicopter, the mixture and cabin heat controls are located one above the other on the left hand side of the control pedestal. The fact that the mixture and cabin heat controls are of the same size and shape probably contributed to the pilot's error in selecting the wrong control.

Department of Transport
Canada.

Jet blast can be VIOLENT!



This incident is not fiction. It is the sort of situation that is occurring all too often at airports served by large jets.* There is no quick and easy solution to the problem. Only by the constant efforts of "combined operations" — pilots, marshallers and despatch engineers alike — can such incidents be eliminated.

Are you doing YOUR part?

* See Aviation Safety Digests, Numbers 50, May 1967 and 60, January 1969.